INSTRUCTION MANUAL

MODEL 440

DIGITAL PICOAMMETER

MP MASTER
MA28514

KEITHLEY INSTRUMENTS

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SPECIFICATIONS

RANGE: 100 picoamperes full scale (0.1 picoampere, least significant digit) to 10 milliamperes in nine decade ranges with 100% overranging on all ranges.

DISPLAY: Four digits from 000 to 1999; polarity and overload indication.

POLARITY SELECTION: Automatic.

RANGE SELECTION: Manual with automatic decimal point positioning.

ACCURACY AND RESPONSE TIME:

Range	Calibrated Accuracy[1] (% of reading)	Range Resistor Stability	Range Resistor Temperature Coefficient	Analog Rise Time[3] (10% - 90%)
10 mA to 100 uA	±0.2% ± 1 digit	0.01%/yr	.005%/°C	less than 1 ms
10 uA	±0.2% ± 1 digit	0.5%/yr	.015%/°C	4 ms
1 uA	±0.2% ± 1 digit	0.5%/yr	.015%/°C	5 ms
100 nA	±0.4% ± 1 digit	1%/yr	.05%/°C	8 ms
10 nA	±0.5% ± 1 digit[2]	2%/yr	.05%/°C	20 ms
1 nA	±0.5% ± 1 digit[2]	3%/yr	.2%/°C	40 ms
100 pA	±0.5% ± 1 digit[2]	3%/yr	.2%/°C	120 ms

1. Calibrated at factory (23°C ambient). Internal adjustments on 100-pA to 10-uA ranges for recalibration.
2. ±3 digits with minimum damping and 500 picofarads shunting the input.
3. With up to 500 picofarads shunting the input and minimum damping.

DAMPING: Varies rise time from minimum value to approximately 1 second on the 100-nanoampere to 100-picoampere ranges.

ZERO DRIFT: Less than 0.5% of full scale per week; less than 0.05%/°C, after ½-hour warm-up with source voltages greater than 2 volts.

DISPLAY RATE: 24 readings per second maximum (20 per second with 50-Hz units) adjustable to approximately two readings per minute.

INPUT VOLTAGE DROP: Less than 1 millivolt for full-scale display on all ranges when properly zeroed.

LINE FREQUENCY REJECTION: 60 dB (ratio of peak-to-peak current of power line frequency or multiple which will cause less than 1 digit of error, to that error). 100 dB on 100-picoampere to 100-nanoampere ranges with maximum damping. Peak input current should not exceed 20 milliamperes.

MAXIMUM INPUT OVERLOAD:

Transient: 1000 volts for up to 3 seconds.

Continuous: 600 V using a Keithley or other current limited (up to 20 mA) High Voltage Supply.

ANALOG OUTPUT: ±1 volt from a 500-ohm source for full-scale display. Maximum output, 1 milliampere. Output polarity is opposite input polarity.

PRINTER OUTPUTS AND OUTPUT CONTROLS: Model 4401 accessory provides BCD output and external controls.

CONNECTORS: Input: Teflon-insulated UHF-type. Analog output: Amphenol 80-PC2F. Case ground: Binding post.

POWER: 105-125 or 210-250 volts (switch selected), 60 Hz. 50-Hz models available. 30 watts.

DIMENSIONS, WEIGHT: 5¼" high x 19" wide x 10" deep; net weight, 15 pounds.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Model 440 is a sensitive digital picoammeter with nine ranges from 100 picoamperes to 10 milliamperes full scale plus 100% overranging.

1-2. FEATURES.

a. Stability. Zero drift with time is less than 1 digit per day; drift with temperature is less than one digit per °C, making frequent adjustment unnecessary.

b. Overload Protection. A transient overload of 1000 volts or a continuous overload of 600 volts at up to 20 mA will not damage the instrument.

c. Damping. A front panel DAMPING control provides additional damping of noisy signals on the 100 nanoampere to 100-picoampere ranges.

d. Digital Display. The digital display provides 3 digits with 0.1 picoampere resolution.

e. Variable Display Rate. A front panel DISPLAY RATE control adjusts from 24 readings/sec. to 2 readings/minute to accommodate the mode of data retrieval.

f. Optional BCD Output and Control Lines. Model 4401 Printer Output Cards are available as an accessory for factory or user installation. This option provides BCD outputs for significant digits, range, polarity, zero check, and overrange. Various remote control lines are also provided. The Output Buffer cards are easily inserted into prewired, premounted, card-edge connectors on the Model 440 chassis.

TABLE 1-1.
Front Panel Controls.

Control	Functional Description	Paragraph
RANGE Switch (S1202)	Sets full range sensitivity.	2-3 a
POWER Switch (S102)	Controls power to instrument.	2-3 b
ZERO CHECK (S1201)	Selects Zero Check Mode.	2-3 c
ZERO ADJUST (R1211)	Adjusts the zero offset.	2-3 e
DAMPING Control (R1221)	Adjusts damping.	2-3 d
DISPLAY RATE (R1201)	Adjusts the A/D Conversion rate.	2-3 f

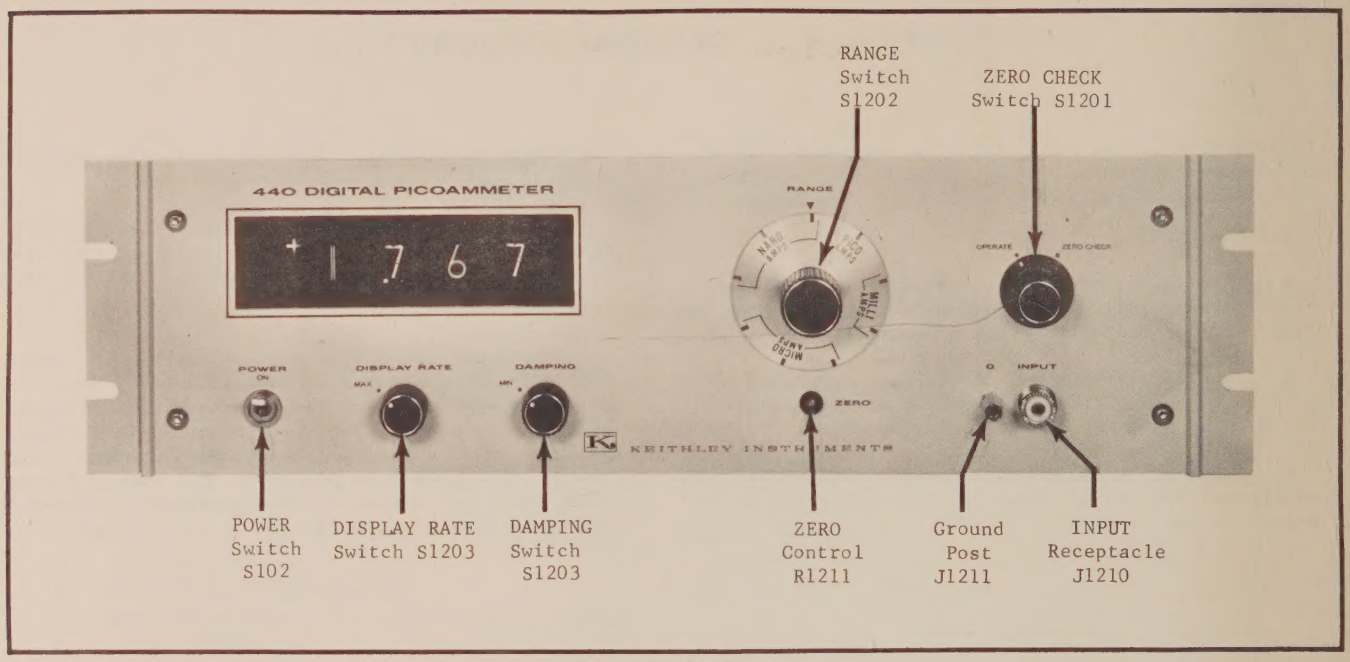


FIGURE 2. Front Panel Controls.

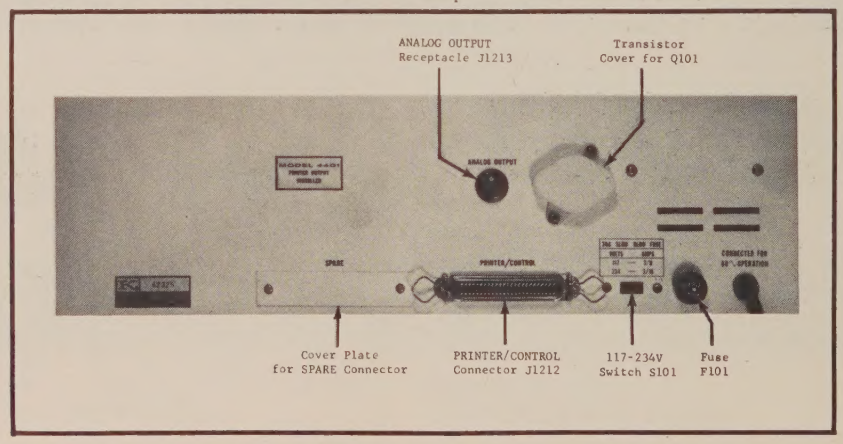


FIGURE 3. Rear Panel Controls and Terminals.

TABLE 1-2.
Rear Panel.

Control or Terminal	Functional Description	Paragraph
117-234V Switch (S101)	Sets 117 or 234V operation.	-
FUSE (F101)	Type 3AG Slow Blow: 117V-3/8A 234V-3/16A	-
ANALOG OUTPUT (J1213)	Provides a recorder output.	2-5
PRINTER/CONTROL (J1212)	Provides BCD Outputs from a 50-pin connector.	2-6
SPARE	Cover plate for mounting an additional 50-pin connector.	2-6

SECTION 2. OPERATION

2-1. INPUT CONNECTIONS.

a. Input Receptacle. The Input connector (J1210) is a Teflon-insulated UHF type (Keithley Part No. CS-64). A mating (CS-49) connector is supplied for making custom cables. The center terminal of the connector is in the Input High terminal while the outer shield is case ground. A separate grounding post "G" is provided for system ground connections.

b. Input Cables. Input connections should be made using coaxial cables which are low-noise types with graphite coating between dielectric and shield braid. For custom length cables Keithley Part No. SC-9 Low Noise Coaxial Cable should be used.

1. Model 2611 Coaxial Cable. This cable is a pre-assembled cable 24 inches long having a UHF male connector on each end.

2. Part No. 19072C Coaxial Test Cable. This cable is a pre-assembled cable 30 inches long having a UHF male connector on one end with alligator clips on the other.

c. Insulation. Use high resistance, low-loss materials such as sapphire, teflon, polyethylene or polystyrene for insulation of the input circuit.

NOTE

The input terminal should be protected from contamination so that the insulation will not be degraded. Clean, dry connections and cables are very important to maintain the value of all insulation materials. Even the best insulation can be compromised by dust, dirt, solder flux, films of oil or water vapor. A good cleaning agent is methyl alcohol, which dissolves most common dirt without chemically attacking the insulation.

2-2. MEASUREMENT CONSIDERATIONS.

a. Noise. The limit of resolution in voltage and current measurements is determined largely by the noise generated in the source. Stray low-level noise is present in some form in nearly all electrical circuits. The instrument does not distinguish between stray and signal currents since it measures the net current. When using the picoampere ranges, consider the presence of low-level electrical phenomena such as thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (die-lectric absorption), and battery action of two terminals (galvanic action).

1. Thermal EMFS. Thermoelectric potentials (thermal emfs) are generated by thermal gradients between two junctions of dissimilar metals. These can often be large compared to the signal to be measured. To minimize the drift caused by thermal emfs, use pure copper leads wherever possible in the source circuit. Drift can also be minimized by maintaining constant junction temperatures especially by using a large heat sink near the connections. The Keithley accessory Model 1483 Low Thermal Connection Kit contains all necessary materials for making very low thermal copper crimp connections for minimizing thermal effects.

2. AC Electric Fields. The presence of electric fields generated by power lines or other sources can have an effect on instrument operation. AC voltages which are very large with respect to the full-scale range sensitivity could drive the ac amplifier into saturation, thus producing an erroneous dc output. Proper shielding as described in paragraph 2-1, d can minimize noise picl-up when the instrument is in the presence of large ac fields or when very sensitive measurements are being made.

3. Magnetic Fields. The presence of strong magnetic fields can be a potential source of ac noise. Magnetic flux lines which cut a conductor can produce large ac noise especially at power line frequencies. The voltage induced due to magnetic flux is proportional to the area enclosed by the circuit as well as the rate of change of magnetic flux. For example, the motion of a 3-inch diameter loop in the earth's magnetic field will induce a signal of several tenths of a microvolt. One way to minimize magnetic pickup is to arrange all wiring so that the loop area enclosed is as small as possible (such as twisting input leads). A second way to minimize magnetic pickup is to use shielding as described in paragraph 2-1, b.

b. Shielding.

1. Electric Fields. Shielding is usually necessary when the instrument is in the presence of very large ac fields or when very sensitive measurements are being made. The shields of the measurement circuit and leads should be connected together to ground at only one point. This provides a "tree" configuration, which minimizes ground loops.

2. Magnetic Fields. Magnetic shielding is useful where very large magnetic fields are present. Shielding, which is available in the form of plates, foil or cables, can be used to shield the measuring circuit, the lead wires, or the instrument itself.

c. Damping. The amount of high frequency noise which will be observed on the picoammeter is determined by: 1) the noise pickup at the input, and 2) the bandwidth of the amplifier circuit. The front panel DAMPING Control (R1221) controls the amount of filtering from a minimum (MIN) value (as stated in the rise time specification) to a maximum value (approximately 1 second on PICOAMP range) when set fully clockwise.

d. Accuracy. The accuracy is specified in terms of a percent of reading on each range. An additional ±1 digit is specified since the A/D conversion has an inherent ±1 digit uncertainty. Noise and source resistance conditions should be evaluated as additional measurement considerations.

e. Source Resistance. The value of source resistance can affect the measurement if the loading effect of the picoammeter is significant. To avoid a degradation of zero drift, the picoammeter range should be selected so that the range feedback resistor is much less than the source resistance. The zero drift specification is valid only for source voltages greater than 2 volts. The suggested minimum source resistance for each range is given in Table 2-1. The amount of degradation of the drift specification is given by the following equation.

$$\text{Drift} = \%/\text{week} \times \frac{\text{Nominal Gain}}{\text{Effective Gain}} = \%/\text{week}\left(\frac{R_S + R_F}{R_S}\right)$$

where Nominal Gain = K

Effective Gain = $\left(\frac{R_S + R_F}{R_S}\right)(K)$

Example: If RANGE = 1 MICROAMP

$R_F = 1.02 \times 10^6$

$R_S = 2 \times 10^6$

Then $\frac{R_S + R_F}{R_S} = \frac{3}{2} = 1.5$

TABLE 2-1.
Suggested Minimum Source Resistances.

RANGE Selected	RANGE Resistance (ohms)	Source Resistance
100 PICO-AMPS	10^{10}	2×10^{10}
1 NANO-AMP	10^9	2×10^9
10 NANO-AMPS	10^8	2×10^8
100 NANO-AMPS	10^7	2×10^7
1 MICRO-AMP	1.02×10^6	2×10^6
10 MICRO-AMPS	1.05×10^5	2×10^5
100 MICRO-AMPS	1.05×10^4	2×10^4
1 MILLI-AMP	1050	2×10^3
10 MILLI-AMPS	105	2×10^2

f. Overloads. A unique input circuit provides complete overload protection with fast recovery. The maximum transient overload is 1000 volts for up to 3 seconds. The maximum continuous overload is 600 volts using a current limited supply (up to 20 mA) such as Keithley Models 240A, 245, or 246.

2-3. FRONT PANEL CONTROLS.

a. RANGE Switch (S1202). This switch selects the full scale display range in nine decade steps. The dial is designated in engineering units, that is, PICO AMPS, NANO AMPS, MICRO AMPS, and MILLI AMPS.

b. POWER Switch (S102). This switch controls the line power to the instrument.

c. OPERATE/ZERO CHECK Switch (S1201). This switch selects either normal operation or zero check operation.

d. DAMPING Control (R1221). This control varies the response time of the picoammeter on the PICO AMP and NANO AMP ranges.

e. ZERO Control (R1211). This control adjusts the zero display. The ZERO Control should be used when in ZERO CHECK mode.

f. DISPLAY RATE Control (R1201). This control adjusts the A/D converter conversion rate from 24 readings/sec. (MAX) to 2 readings/min (approx).

2-4. OPERATING PROCEDURE.

a. Preliminary Procedure.

1. Check the 117-234V Switch (S101) on the rear panel for proper line voltage.

2. Check for proper rated fuse.

3. Connect the power cord, place the POWER switch ON, and allow a 30 minute warmup for critical measurements.

4. Adjust the ZERO Control (R1211) as necessary. Zero is indicated by alternately flashing ± polarity lights.

5. Connect the source as described in paragraph 2-1.

b. Measurements. The Model 440 measures current over a full-scale range from 10 milliamperes (10^{-2} A) to 100 picoampere (10^{-10} A) with resolution to 0.1 picoampere (10^{-13} A). The display will indicate either a positive or negative input current automatically. (A positive current is defined as a positive "conventional current" applied at Input High with respect to case ground.)

TABLE 2-2.
Decimal Point Display.

RANGE	Decimal Point Position
100 PICO-AMPS	XXX.X
1 NANO-AMP	X.XXX
10 NANO-AMPS	XX.XX
100 NANO-AMPS	XXX.X
1 MICRO-AMP	X.XXX
10 MICRO-AMPS	XX.XX
100 MICRO-AMPS	XXX.X
1 MILLI-AMP	X.XXX
10 MILLI-AMP	XX.XX

c. Digital Display. The display has three digits plus one for overrange indication. The RANGE Switch selects the range sensitivity and the location of the decimal point. Table 2-2 shows the position of the decimal point for each RANGE position. In order to interpret the full scale current range, the ranges are shown expressed in scientific notation in Table 2-3.

TABLE 2-3.
Typical Full Scale Readings.

Input Current	RANGE	Display	Exponent
1×10^{-10} A	100 PICO-AMPS	100.0	$\times 10^{-12}$
1×10^{-9} A	1 NANO-AMP	1.000	$\times 10^{-9}$
1×10^{-8} A	10 NANO-AMPS	10.00	$\times 10^{-9}$
1×10^{-7} A	100 NANO-AMPS	100.0	$\times 10^{-9}$
1×10^{-6} A	1 MICRO-AMP	1.000	$\times 10^{-6}$
1×10^{-5} A	10 MICRO-AMPS	10.00	$\times 10^{-6}$
1×10^{-4} A	100 MICRO-AMPS	100.0	$\times 10^{-6}$
1×10^{-3} A	1 MILLI-AMP	1.000	$\times 10^{-3}$
1×10^{-2} A	10 MILLI-AMPS	10.00	$\times 10^{-3}$

2-5. ANALOG OUTPUT. The analog output on the rear panel (J1218) provides a voltage of 1.05 volts corresponding to 1.000 on any range. Since this output has a source resistance of 499 ohms, the recording device must have a load resistance greater than 10 kilohms to obtain 1.000 volt for full range. If a recorder such as the Keithley Model 370 is available, an Isolation Amplifier (such as Keithley Model 399) must be used to provide up to 1 milliampere current for full range.

2-6. DIGITAL OUTPUT.

a. General.

1. The Model 440 has provision for the installation of output buffer printed circuit boards to obtain Binary Coded Decimal (BCD) outputs. Two 44-pin card-edge connectors are installed and completely wired on the main PC board.

2. A factory-wired 50-pin PRINTER/CONTROL Connector is provided on the rear panel. This connector is wired to provide signals as described in Table 2-1. This Amphenol (Blue Ribbon Series) connector can be ordered with special wiring configurations.

3. Output buffer cards available from Keithley as Model 4401 Printer Output Cards, may be ordered factory installed or ordered at a later date for user installation, since no soldering or rewiring is required. These Output Cards are available with other codes (Standard Code is 1-2-4-8) on a custom design basis.

b. Output Codes and Levels.

1. The PRINTER/CONTROL Outputs are Binary Coded Decimal (BCD) signals with 1-2-4-8 Standard Code.

2. The Standard signal levels are as follows:
Logic "0" 0.4 vol
Logic "1" +10 volts at up to 1 milliampere

c. Output Information.

TABLE 2-4.
Model 4401 Printer Output Cards.

Model 4401 Printer Output Cards: Provide BCD output and external control of Model 440 may be purchased installed or separately for field installation (no wiring required).
Printer Outputs: BCD positive output represents each of the four digits, exponent, sensitivity, polarity and overrange. Standard code is 1-2-4-8. "0" +0.4 volt; "1" +10 volts at up to one milliampere; 0 = 0000.
Print Command: Positive pulse of 14 volts from a 2200-ohm source with 1 volt per microsecond rise time, 100 microseconds minimum pulse width. Print command given after each A to D conversion.
Remote Controls:
Hold #1: Closure to ground inhibits A to D conversion at that instant.
Hold #2: Closure to ground inhibits A to D conversion after reading has been completed.
Trigger: Closure to ground initiates one conversion when in Hold #2. Integration period starts 8.3 ms (10 ms on 5-Hz models) after "Trigger" or release of Hold #2.
Connector: 50-pin Amphenol Micro-Ribbon mounted on Model 440. Output mating connector supplied with 4401.

NOTE

The term "Closure to Ground" or "Grounded control line" means a short to common directly or through a saturated NPN transistor (V_{CE} +0.4V). Only the "COMMON" as supplied at the PRINTER/CONTROL connector should be used for closures to ground.

1. Full Scale Magnitude. The magnitude of the reading is indicated by BCD outputs which correspond to the three front panel display lights as shown in Table 2-5.

TABLE 2-5.
Full Scale Magnitude

Connector Pin No.	Output	Decimal Digits
1	1×10^0	1
2	2×10^0	2
26	4×10^0	4
27	8×10^0	8
3	1×10^1	1
4	2×10^1	2
28	4×10^1	4
29	8×10^1	8
5	1×10^2	1
6	2×10^2	2
30	4×10^2	4
31	8×10^2	8

2. Overrange Indication. Overrange is indicated by the fourth (from the right) display light and corresponding BCD output as shown in Table 2-6. Overload is indicated by a blanked display and corresponding BCD output. The output at pin 33 will be a logic "1" when the magnitude of the digital display exceeds 1999.

TABLE 2-6.
Overrange and Overload Outputs.

Connector Pin No.	Output	Decimal Digits
7	1×10^3	1
8	Common (2×10^3)	0
32	Common (4×10^3)	0
33	Overload (8×10^3)	8

3. Polarity Indication. The polarity is indicated automatically by the Polarity Indicator and corresponding BCD output as shown in Table 2-7. Additional BCD levels are available at pins 14 and 39 for use with some printers. The zero check mode is indicated by a BCD output from pin 38. Four pins may be used to obtain BCD polarity codes for external printers, where 1010 = + and 1011 = - printer characters.

TABLE 2-7.
Polarity Output.

Connector Pin No.	Output	Decimal Digits
13	Polarity (1×10^0)	1
14	+15V	2
38	Zero Check (4×10^0)	4
39	+15V	8

4. Range Indication (Exponent). The range or exponent has a corresponding BCD output as shown in Table 2-8. The print-out of the RANGE Switch exponent uses 2 columns to represent information for exponents from 00 thru 10.

TABLE 2-8.
Range or Exponent Indication.

Connector Pin No.	Output	Decimal Digits
9	1×10^0 Range	1
10	2×10^0 Range	2
34	4×10^0 Range	4
35	8×10^0 Range	8

d. External Control.

1. General. To obtain optimum system performance, it is often desirable to operate the Model 440 synchronously with other digital equipment, such as printers, paper tape punches, computers and other data handling devices. The Model 440 with 4401 Printer Cards installed provides several printer control commands for the purpose of synchronizing external equipment to achieve maximum conversion rates.

2. Applications. Several alternate approaches may be used in designing the overall system control scheme.

a) The Model 440 can be used to provide master control of external devices so that the maximum possible conversion rates can be obtained.

b) An external device can also be used for master control such as a high speed printer.

c) A completely independent "master clock" can be used for system control for maximum flexibility.

3. Description of external controls.

a) "HOLD 1". This control inhibits A to D conversion at the instant a closure to ground is made. The conversion cycle will resume immediately when the "HO D 1" line is opened.

b) "HOLD 2". This control inhibits A to D conversion after a complete reading cycle. Further conversions are inhibited as long as a closure to ground is made. The conversion cycle will resume immediately when the "HOLD 2" line is opened.

c) "TRIGGER". This control initiates one complete conversion when "HOLD 2" line is grounded. Closure to ground may be momentary or any longer duration to initiate a conversion

d) "PRINT COMMAND". This control provides a positive going pulse of 14 volts after a complete A to D conversion is made and all data line outputs are final readings.

4. Power Supply Voltages. The PRINTER/CONTROL Connector also provides power supply voltages of +15, -15, and +3.6 volts as shown in Table 2-9.

TABLE 2-9.

Voltage	Maximum Load Current	Pin No.
+3.6 V	+50 mA	18
+15 V	+10 mA	14,17,39
-15 V	-10 mA	42

5. High and Low Reference. The PRINTER/CONTROL Connector provides two reference voltages, High (+8V) and Low (+2V). These levels may be used to define the "HIGH" and "LOW" digital output states for external printing or computer devices.

e. Summary of Digital Outputs and Controls.

1. Standard Output Codes and Levels. The standard output code for Model 4401 Printer Output Cards is 1-2-4-8 Binary Coded Decimal (BCD). A binary coded decimal digit is represented by a four-bit binary code as shown in Table 2-12. Refer to Figure for a circuit diagram of the Model 4401 Standard Printer Output buffer stage.

2. PRINTER/CONTROL Connector. The PRINTER/CONTROL Connector used on the Model 440 provides for connections to 50 pins as shown in Table 2-11. The mating connector supplied with Model 4401 is an Amphenol Part Number 57-30500 or Keithley Part Number CS-220, available on special order.

3. Analog-to-Digital Conversion Cycle.

a) The analog-to-digital conversion cycle can be initiated in any one of three ways.

1.) DISPLAY RATE Control Set at MAX. With the DISPLAY RATE Control set at MAX, the end of one complete conversion triggers a second conversion to obtain the maximum conversion rate of 24 readings per second.

2.) DISPLAY RATE Control Set at Other Than MAX. With the DISPLAY RATE Control set at some position other than MAX, (uncalibrated control setting) the end of one complete conversion triggers a second conversion which is delayed by a specific time interval (DELAY). The time delay is a function of the position of a continuously variable control to provide a conversion rate from 24 readings per second to 2 readings per minute.

3.) "HOLD 2" with TRIGGER Control. With the "HOLD 2" command grounded, a closure to ground of the "TRIGGER" command initiates one complete conversion cycle. A second conversion will follow only if the TRIGGER command is removed and re-applied a second time. The maximum conversion rate using an external trigger is 24 readings per second.

TABLE 2-10.
Typical Digital Outputs.

Front Panel Digital Display	RANGE Setting	Polarity	Significant Digit & Overload	Mag.	Range Exp.	Interpretation
-093.6	PICO-AMP	-	0	936	-	-0.936×10^{-10}
+0.275	NANO-AMP	+	0	275	09	$+0.275 \times 10^{-9}$
-17.31	NANO-AMP	-	1	731	08	-1.731×10^{-8}
+122.3	NANO-AMP	+	1	223	07	$+1.223 \times 10^{-7}$
+0.096	MICRO-AMP	+	0	096	06	$+0.096 \times 10^{-6}$
-07.81	MICRO-AMP	-	0	781	05	-0.781×10^{-5}
+165.2	MICRO-AMP	+	1	652	04	$+1.652 \times 10^{-4}$
-1.921	MILLI-AMP	-	1	921	03	-1.921×10^{-3}
-06.37	MILLI-AMP	-	0	637	02	-0.637×10^{-2}
+(blank)	MICRO-AMP	+	8	000	05	positive overload

TABLE 2-11.
PRINTER/CONTROL Connector Pin Identification.

Pin No.	Output	Function	Pin No.	Output	Function
1	1×10^0	Data	26	4×10^0	Data
2	2×10^0	Data	27	8×10^0	Data
3	1×10^1	Data	28	4×10^1	Data
4	2×10^1	Data	29	8×10^1	Data
5	1×10^2	Data	30	4×10^2	Data
6	2×10^2	Data	31	8×10^2	Data
7	1×10^3	Data	32	Common	---
8	Common	---	33	8×10^3	Overload
9	1×10^0	Range	34	4×10^0	Range
10	2×10^0	Range	35	8×10^0	Range
11	1×10^1	Range	36	Common	---
12	Common	---	37	Common	---
13	1×10^0	Polarity	38	1×10	Zero Check
14	+ 15V	---	39	+ 15V	---
15	Blank	---	40	Blank	---
16	Blank	---	41	Blank	---
17	+ 15V	---	42	- 15V	---
18	+ 3.6V	---	43	Common	---
19	Blank	---	44	Grounded	Hold #1
20	Blank	---	45	Grounded	Hold #2
21	Blank	---	46	Grounded	Trigger
22	Blank	---	47	Blank	---
23	+ 14V Pulse	Print Command	48	Blank	---
24	+ 8V	Hi Reference	49	Blank	---
25	+ 2V	Low Reference	50	Blank	---

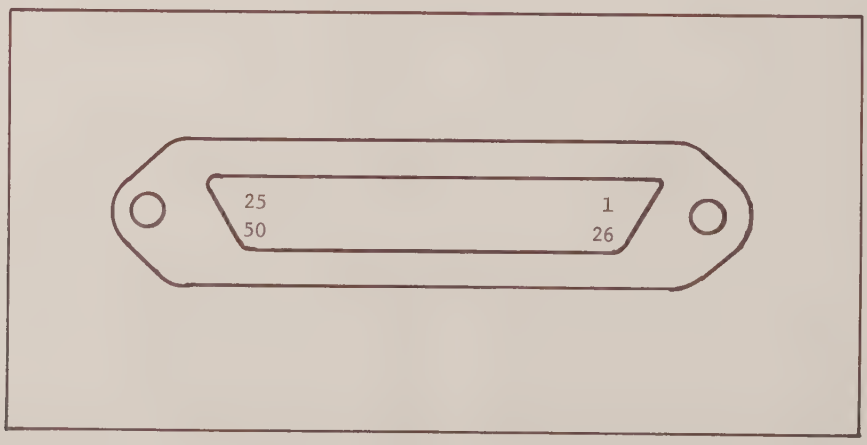


FIGURE 4. Printer/Control Connector.

b) Conversion Cycle Timing. The Conversion Cycle is composed of three timing periods, namely, Integrator Zero, Integrator Sampling, and A-D Counting period. Refer to Timing Diagram Figure

1.) Integrator Zero Period (ZERO). When a trigger pulse initiates a new conversion cycle, the Integrator circuit is zeroed for a period not to exceed 8.33 milliseconds for 60 Hz operation. The Integrator Zero Period is 10.00 milliseconds for 50 Hz operation.

2.) Integrator Sampling Period (INTEGRATE). The Integrator Sampling Period follows automatically the Integrator Zero Period and lasts for a duration of 16.67 milliseconds for 60 Hz operation. The Integrator Sampling Period lasts for a duration of 20.00 milliseconds for 50 Hz operation.

3.) A-D Counting Period (COUNT). The A-D Counting Period is initiated immediately following the Integrator Sampling Period. The actual counting time duration will depend on the actual integrator voltage up to a maximum of 2000 clock pulses or 16.67 milliseconds. Following the counting period a Buffer/Storage command is automatically generated in order to store the new reading in the output registers.

4.) PRINT COMMAND. The PRINT COMMAND signal is used to trigger external printers or paper tape punches. The PRINT COMMAND signal is delayed 10 microseconds to allow the Storage Registers to settle. The PRINT COMMAND pulse width is approximately 100 microseconds with a 1 volt/microsecond rise time into a 1 kilohm load. The pulse amplitude is approximated by the following equation:

$$e_o = 14R/(R + 2200)$$

where R is the output load resistor.

The "OFF" state is less than +0.4 volt with approximately 1 milliampere sink current.

NOTE

The data stored in the Output Registers will not change for at least 25 milliseconds for 60 Hz operation. If the front panel controls are changed, the Zero Check BCD output will be changed only .

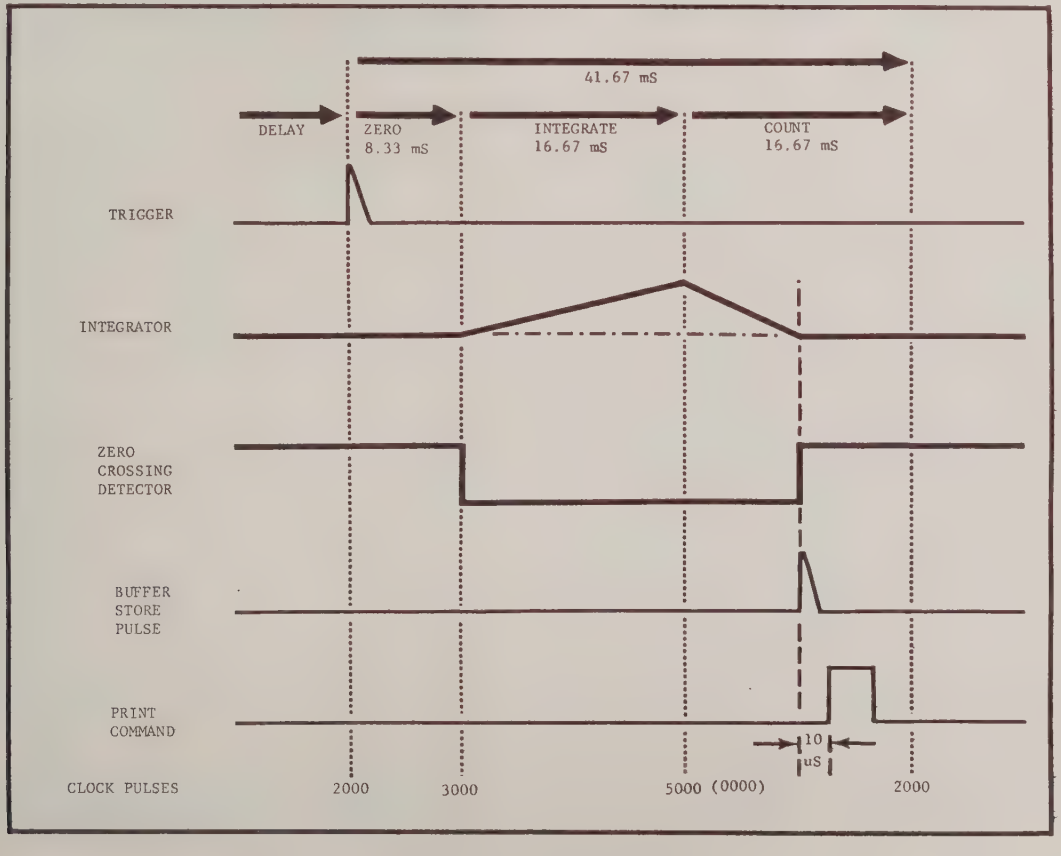


FIGURE 5. Timing Diagram.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 440 Digital Picoammeter consists of two separate sections packaged together in one chassis for optimum performance and convenience: a sensitive picoammeter and an analog-to-digital converter.

a. Picoammeter. The picoammeter is a linear dc amplifier connected as a feedback ammeter with nine current ranges.

b. A/D Converter. The analog-to-digital converter is a dual slope, integrating type converter with medium conversion rate, cold cathode readout tubes, BCD output options and external control.

3-2. PICOAMMETER

a. Operation. The picoammeter consists of a sensitive, linear dc amplifier with a 1 volt full scale sensitivity. The amplifier provides an analog output up to 2 volts for a 100% overrange display. The RANGE resistors are connected across the feedback of the amplifier. A simplified diagram of a feedback ammeter is shown in Figure 6.

b. Circuitry. The amplifier input stage is a pair of insulated-gate, field-effect transistors (IGFET) designated Q1201 and Q1202 connected in a differential configuration. The circuit designated 21850B is a special overload protection circuit on the Input FET board (which connects to J1201). The gate of Q1201 is connected to the input through 10M ohms. The gate of Q1202 is referenced to ground. Potentiometer R1205 is an internal COARSE ZERO adjustment. Potentiometer R1206 is an internal Balance control. Transistors Q1203-Q1204 form a second differential amplifier stage. Potentiometer R1211 is a front panel ZERO adjustment. Transistor Q1205 and emitter follower transistor Q1206 provide sufficient gain for the analog output and A/D converter. The analog output is connected through R614 (499Ω) to the dc amplifier output (the junction of R1220 and D1203). The full scale current sensitivity is determined by the range resistor connected across the feedback. The range resistance R_F is composed of a fixed resistance R_1 plus a calibration adjustment resistance R_2 as shown in Figure 7. Potentiometer R1221 controls the amount of damping on the PICO AMP and NANO AMP ranges only. Switch S1203 defeats the damping feature when set to "MIN" or open position. The damping circuit is shown in Figure 8. When switch S1201 is set to ZERO CHECK the picoammeter is connected as shown in Figure 9. It should be noted that the feedback resistor R_F is shorted out and the input High terminal is shorted to ground.

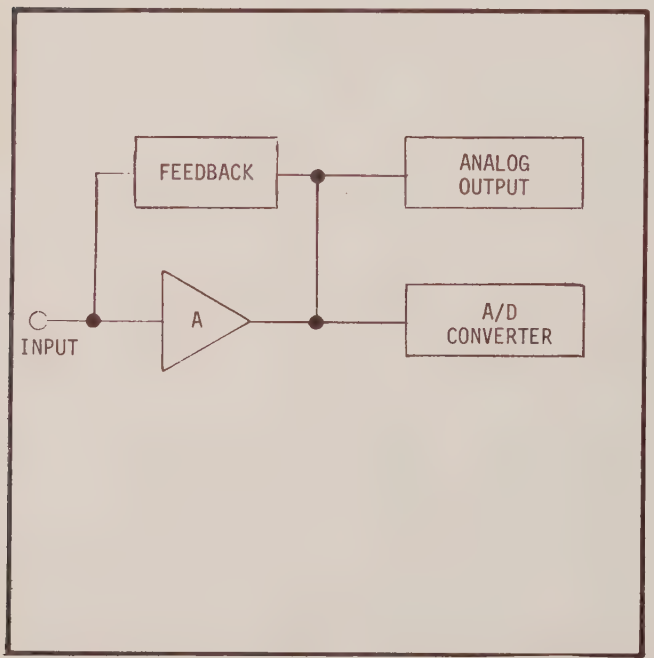


FIGURE 6. Simplified Diagram of Feedback Ammeter.

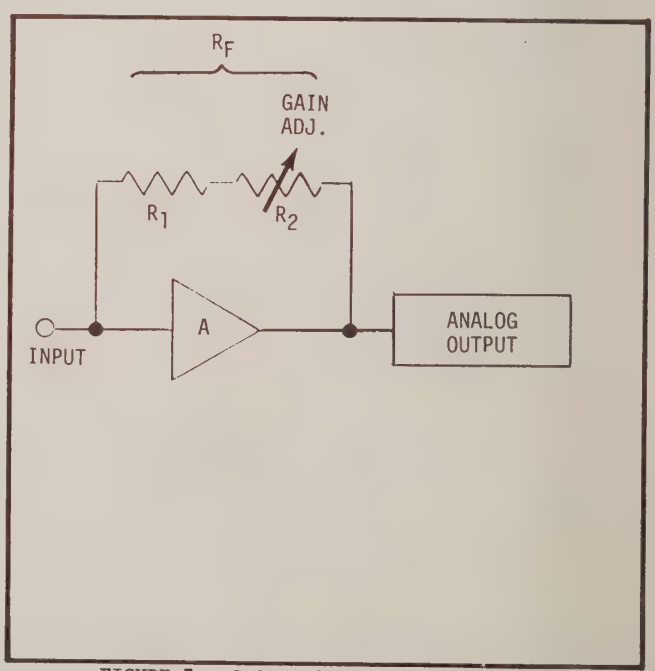


FIGURE 7. Gain Calibration of Amplifier.

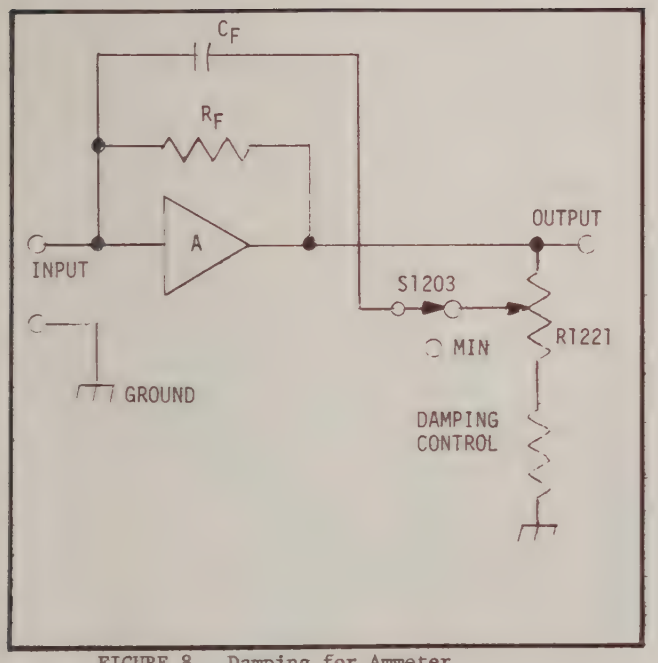


FIGURE 8. Damping for Ammeter.

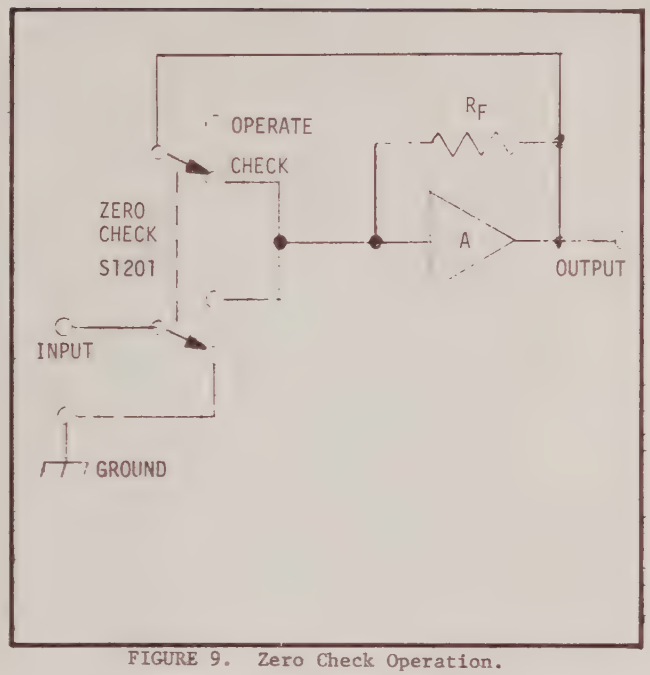


FIGURE 9. Zero Check Operation.

3-4. ANALOG-TO-DIGITAL CONVERTER OPERATION.

a. General. A detailed block diagram of the A/D converter is shown in Figure 10. The analog-to-digital converter operates using a dual slope integration technique which has inherent line frequency noise rejection. The analog signal is applied to the integrator for one complete line frequency cycle. The analog signal is then removed from the integrator input. The voltage on the integrator is then driven to zero to complete the voltage-to-time conversion. The time interval to reach a "Zero Crossing" is counted and displayed on the "Readout" in proportion to the original analog signal. The sequence is then repeated for a second reading. A Timing Diagram is shown in Figure 5.

b. Circuits. The A/D Converter is composed of nine major circuits which perform the analog-to-digital conversions and provide various control commands.

1. Oscillator or Clock
2. BCD Counter
3. Delay Hold
4. Program/Decoder
5. Integrator
6. Zero Crossing Detector
7. Buffer/Storage Register
8. Decoder/Driver
9. Numerical Readout

c. Oscillator or Clock. The Oscillator produces pulses at a rate of 120 kilohertz for Electrometer using 60 Hz line power. The 50 Hz units have a pulse rate of 100 kilohertz.

d. BCD Counter. The BCD Counter counts the Clock pulses with a total range of 5000 counts. The Counter is composed of 4 individual counters designated 1, 10, 100, and 1000.

1. The "1", "10", and "100" counters have a capacity of ten counts each.

2. The "1000" counter has a capacity of five counts.

3. The total capacity of all four counters is 5000 counts.

e. Delay Hold. The Delay Hold circuit controls the DISPLAY RATE function and external Hold and Trigger commands as shown in Figure 11. It determines the length of time between A/D conversions when the front panel DISPLAY RATE Control is set to any position other than MAX. The clock is stopped at the beginning of the ZERO (2) period for a time determined by the rotation of the DISPLAY RATE Control. It ensures that when the Hold 2 is grounded the conversion in process will be completed and new data will be stored in the output storage register. Then the clock will be inhibited at the beginning of the ZERO period (2). The instrument will remain in this condition indefinitely until Hold 2 is released or until Trigger is shorted to ground. After conversion, the instrument will again be inhibited at the beginning of the period (2). If both Switches S_1 and S_2 are closed, the conversion cycle works in the following manner. After the previous conversion has been completed, the leading edge of the program command (2) resets the flip-flop. In this new condition $\overline{Q}$ is high and, therefore, the clock gives no output. At that time, the unijunction timer begins its cycle and, after the appropriate time, produces a pulse that sets the flip-flop. This changes $\overline{Q}$ to a low state and a new conversion cycle begins. After the reading has been completed, the (2) command again resets the flip-flop and the timer again issues a new pulse to set the flip-flop.

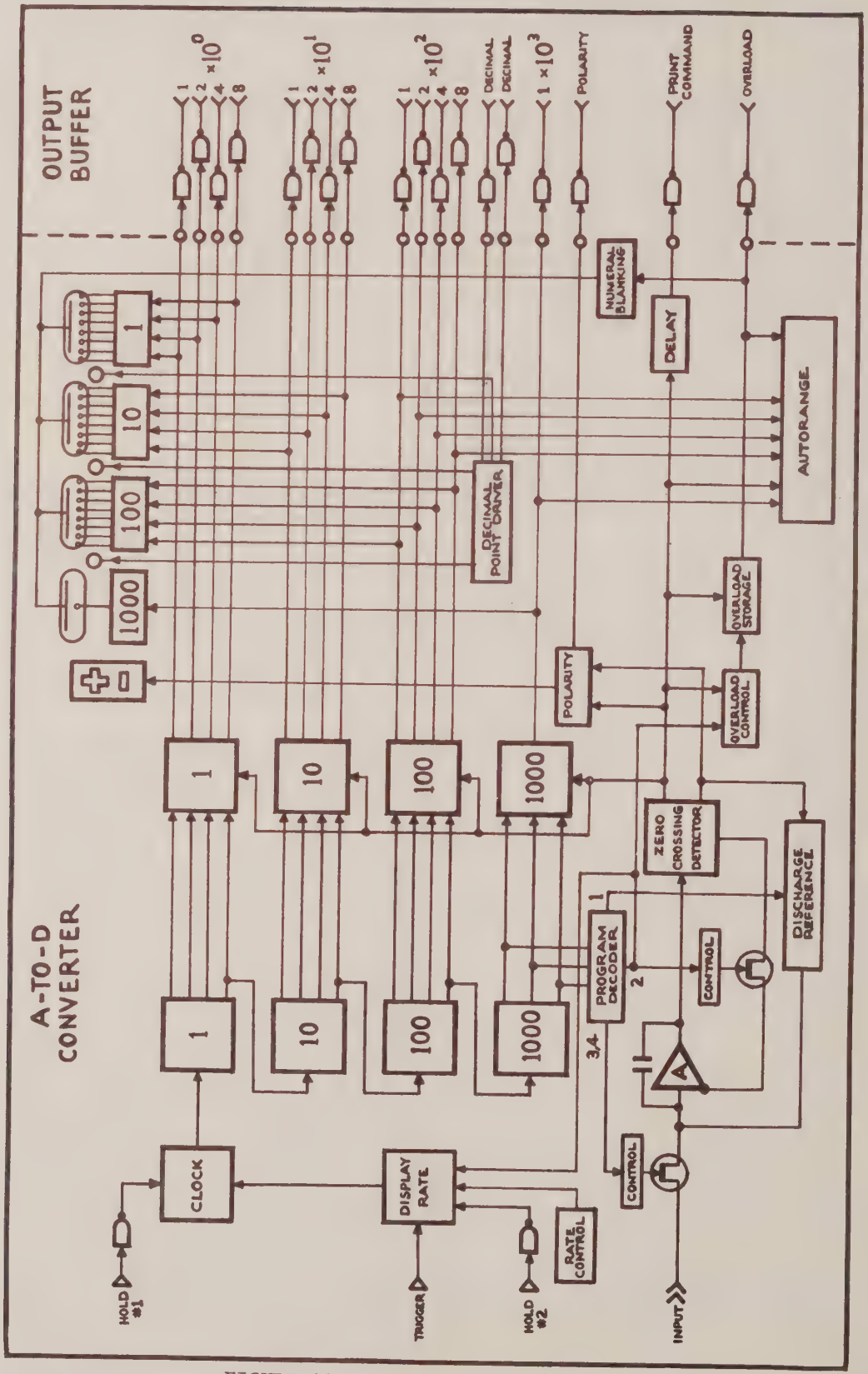


FIGURE 10. Block Diagram of A/D Converter.

f. Program/Decoder. The Program/Decoder circuit produces event commands to control the overall sequence of events for a complete A/D conversion.

g. Integrator. The Integrator circuit operation is composed of three periods.

1. Zero Period. During this period the integrator amplifier is zeroed by the closure of switch S_b. Switches S_a, S_c, and S_d are open to prevent integrator charging as shown in Figure 12.

2. Integration Period. During this period, switch S_b, S_c, and S_d are open. Switch S_a is closed to permit charging by the analog voltage for a period of one line cycle.

3. Discharge Period. During this period, switch S_a is open to prevent further charging by the analog signal. Either switch S_c or S_d is closed to drive the Integrator voltage to zero. A reference current of opposite polarity to the input current is applied through either switch S_c or S_d. The Discharge Period ends when the Zero Crossing Detector circuit detects a zero Integrator output.

h. Zero Crossing Detector. The Zero Crossing Detector circuit provides a "High" or "Low" level output depending on the polarity of the detected input. Refer to Table 3-1 for a description of voltage outputs.

TABLE 3-1.
Zero Crossing Detector Output Levels.

M	N	B	C
0V	-0.5V	+1.5V	0V
0V	+3.5V	0V	+1.5V

i. Buffer/Storage Register. The Buffer/Storage Register is composed of "flip-flops" arranged to copy the states of the various BCD counters. The Buffer/Storage Register requires a Buffer Store command before any information can be transferred. The "flip-flop" circuits provide coded information for Decoder/Driver and the BCD outputs.

j. Decoder/Driver. The Decoder/Driver circuit decodes the BCD information from the Storage Register into ten-line decimal code. The Driver circuit then drives the proper numeral in each of the Numerical Readout tubes.

k. Numerical Readout. The Numerical Readout consists of four numerical indicators and one polarity indicator driven by the Decoder/Driver, Polarity and Overload Drivers.

1. Summary of Operation. The operation of the A/D Converter can be described by considering a typical conversion cycle.

1. The Oscillator or Clock provides pulses at a rate of 120 kilohertz.

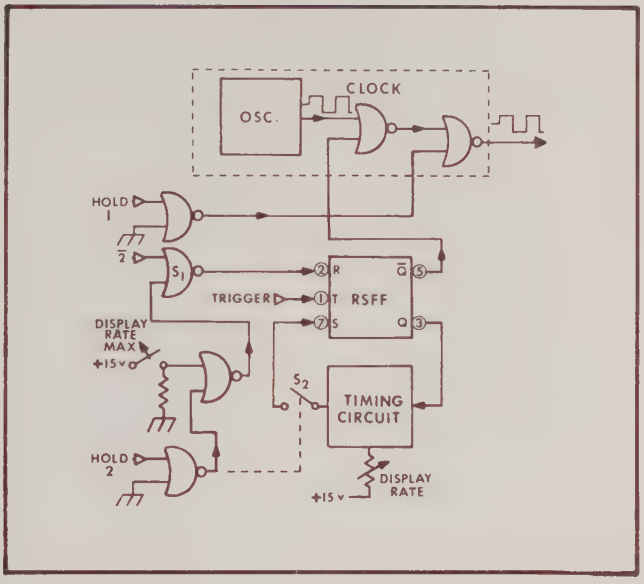


FIGURE 11. Delay Hold Circuit

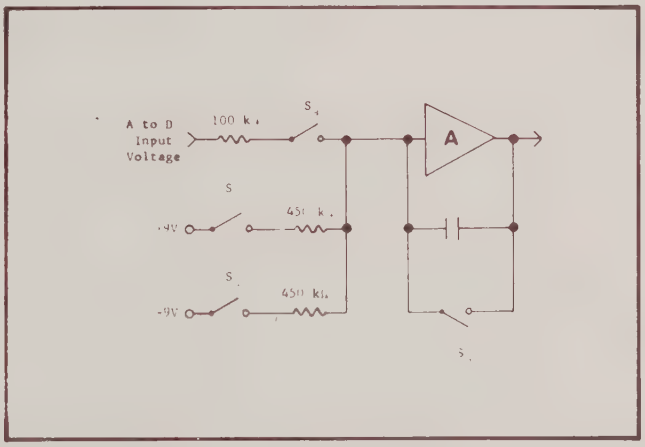


FIGURE 12. Integrator Circuit

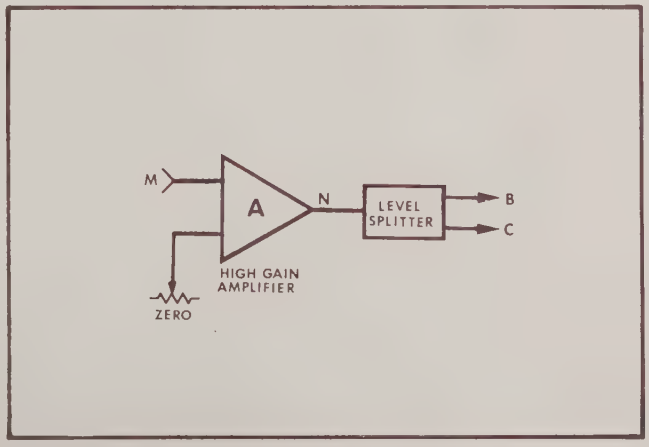


FIGURE 13. Zero Crossing Detector

2. The Delay Hold circuit gates the output of the Oscillator depending on the state of the "RS flip-flop" and the "Hold 1" control line. A unijunction timing circuit provides a delay period before a conversion is initiated. The time delay is selected by the front panel DISPLAY RATE Control.

3. The BCD Counter serves as a master timing control for the A/D conversion cycle. The timing is accomplished by the "1000" counter which has five coded states, namely 0, 1, 2, 3, and 4.

4. The Program/Decoder controls the sequence of commands based on the coded states from the BCD Counter. The decoded commands are described as shown in Table 3-2. The "2" command initiates the integrator ZERO period which removes any residual charge on the integrator capacitor. The "3,4" command initiates the INTEGRATE period which permits an integration of the analog signal. At the end of the INTEGRATE period, the "0,1" command initiates the COUNT period.

TABLE 3-2.

Command	Function
2	ZERO
3,4	INTEGRATE
0,1	COUNT

5. When the "3,4" command is given, the integrator is charged by the analog signal for a period of 1 line cycle of 16.67 milliseconds.

6. When the "0,1" command is given, the analog signal is removed and the integrator output is driven to zero by a reference current. The Zero Crossing Detector senses a zero crossing of the Integrator output and removes the reference current. The Detector provides outputs as shown in Table 3-1. The +1.5 volt levels are provided for control of the Integrator and Polarity Storage Register. A pulse command is also produced to initiate a Buffer/Store and Print Command output.

7. When the Buffer/Store command is given, the Buffer/Storage Register copies the BCD Counter-states at that instant of time. The BCD coded information in the Register is then available for the Decoder/Driver and external printout.

8. The Decoder/Driver decodes the Buffer/Storage output and drives the Numerical Readout for a digital display.

9. The BCD Output information is available at the Model 4401 Buffer Card outputs in the form of positive (+10 volt) true logic (1-2-4-8 BCD Code).

10. The conversion cycle is complete when the BCD Counter reaches 2000 counts and the Program/Decoder provides a "2" command to initiate a new conversion cycle.

11. The Unijunction Timing Circuit will initiate the ZERO period after a present time delay controlled by the front panel DISPLAY RATE Control.

3-5. ANALOG-TO-DIGITAL CONVERTER CIRCUITRY.

a. General. The circuits described in this section are located on the various Sub-Assemblies listed below and in Table 7-2 of Section 7.

1. Oscillator Board, PC-217.
2. Integrator Board, PC-219.
3. Display/Overload Board, PC-241.
4. Readout Board, PC-229.
5. Polarity Board, PC-207.
6. Output Buffer Board, PC-218.
7. Output Buffer Board, PC-209.

b. Oscillator Board. The Oscillator Board contains portions of three circuits: the Ocsillator (clock) circuit, the Delay/Hold circuit, and the Discharge-Voltage Current Source circuit.

1. Oscillator Circuit. Transistor Q501, crystal Y501, and phase shift capacitors C501, and C502 form a "Colpitts" type oscillator. Capacitors C503 and C504 are used for trimming the oscillator frequency. The output is taken from the collector of transistor Q510 which is a common emitter gain stage used for squaring the output. Transistor Q507 serves as an emitter-follower to reduce output impedance.

2. Delay/Hold Circuit. There are three major components in the Delay/Hold circuit: an "RS" type flip-flop circuit, a "Unijunction" timing circuit and a "Hold" gate circuit.

a). "RS" Type Flip-Flop Circuit. The flip-flop gates the output of the clock depending on the inputs at pins R and S. The RS flip-flop is constructed of gates QA501B and QA501C. The pins are identified as shown in Figure 16.

b). "Unijunction" Timing Circuit. The unijunction timing circuit determines the time delay between conversion cycles to obtain the desired conversion rate as determined by the front panel DISPLAY RATE Control. The circuit is composed of transistors Q513 and Q514, timing capacitor C507, and timing resistors R532 and R1269 (DISPLAY RATE Control potentiometer located on the front panel).

c). "HOLD" Gate Circuit. Refer to Figure 13 for identification of switches S_1 and S_2. The "HOLD" gate circuit is composed of gates QA501A, QA501D, and QA502 (A, B, C, and D). Switch S_1 is gate QA501A and is controlled by either the "HOLD 2" external line or the "MAX" position on the DISPLAY RATE Control. Switch S_2 is the transistor Q513 which is controlled by either the "Q" output of the flip-flop or the "HOLD 2" external line. The "HOLD 1" circuit is composed of gates QA502B and QA502C.

3. Discharge-Voltage Current Source Circuit. The positive current source composed of transistors Q502 and Q506 delivers a constant current of +7.5 milliamperes to drive a 9-volt zener diode D602 (located on the Integrator Board, PC-246) when +REF Terminal (Pin 13) is greater than +0.7 volt. The negative current source composed of transistors Q508 and Q509 delivers a constant current of -7.5 milliamperes to drive a 9-volt zener diode D601 also located on the Integrator Board, PC-219.

c. Integrator Board. The Integrator Board consists of two major circuits: the Integrator circuit and the Zero Crossing Detector circuit.

1. Integrator Circuit. The operation of the Integrator is controlled by the positions of switches S_a, S_b, S_c, and S_d. Switch S_a is transistor Q605. Switch S_b is transistor Q606. Transistors Q601 through Q604 are control circuits arranged to turn off the proper FET switches depending on the signals at pins 11 and 12. The integrator amplifier consists of transistors Q607 and Q608 and integrated circuit QA601. The feedback capacitor is C603. Switches S_c and S_d (located on the Oscillator Board, PC-217) control the current for 9-volt zener diodes D601 and D602. Resistors R602 through R611 are full-scale calibration resistors.

2. Zero Crossing Detector Circuit. (Refer to Figure 18). The high gain amplifier is composed of cascaded amplifiers QA602 and QA603. The zero adjustment network consists of resistors R645, R646, R648, R649, and R650, and diodes D611 and D612. Transistor Q609 and other components form a 6-volt supply for QA603 and the zero circuit. The level-splitter circuit consists of diodes D613 and D614, resistors R651, R652, and R653 and gates QA604 (A, B, C).

d. Display/Overload Board. The Display/Overload Board contains a BCD Counter ("1000" counter), a Program Decoder circuit, and an Overload Control circuit.

1. The BCD Counter is composed of "J-K" flip-flop circuits QA301 and QA302.

2. The Program Decoder circuit is composed of gates QA303C and QA303D (3,4 Command) and QA304A, QA304B, QA304C, QA304D, QA305A, QA305B, QA305C, QA305D, QA303E, QA306A, QA306B, and QA306C (0,1 & 2 Commands).

3. The Overload Control circuit provides an overload signal if a zero crossing does not occur in the Discharge Period (0,1). It controls the Numerical Blanking circuit and provides an Overload Print signal.

e. Readout Board. The Readout Board contains Decade Counter circuits, Buffer Storage circuits, and Decoder Driver and Display circuits.

1. Decade Counter Circuits. Each decade counter is composed of four J-K flip-flops. Circuits QA401 through QA406 are Dual J-K Flip-Flop integrated circuits.

2. Buffer Storage Circuits. The Buffer Storage register is composed of Dual J-K Flip-Flop integrated circuits QA409 through QA414.

3. Decoder Driver Circuits. QA415, QA416, and QA417 are Decimal Decoder Driver integrated circuits.

4. Display Circuits. V401, V402, and V403 are Readout Tubes for Units, Tens, and Hundreds respectively.

f. Polarity Board. The Polarity Board contains various circuits which are controlled by signal "B" and "C" from the Zero Crossing Detector signal as shown in Figure 13.

1. Polarity Indicator Control Circuit. This circuit drives the Polarity Indicator DS201 to provide a Polarity display. QA201A and QA206A are J-K Flip-Flop circuits which control transistors Q201 and Q202.

2. Polarity Print Signal Circuit. The Polarity Print signal is determined by the Q output of J-K flip-flop QA206A.

3. Discharge Voltage Polarity Control Circuit. The +REF Control signal is determined by QA201A and gate QA204A. The -REF Control signal is determined by QA202A, QA203A, QA203B, QA202B, QA202C, QA203C, QA203D, and QA207A.

4. Buffer Store Command Circuit. The Buffer Store command is provided by J-K flip QA201B and gates QA204C and QA207A.

5. Overload Blanking Circuit. A portion of the Overload Blanking circuit QA204D, QA206B, and QA207B is located on the Polarity Board. The remainder of the circuit is located on the Display/Overload Board PC-241.

g. Output Buffer Board, PC-218. This board contains 15 buffer circuits to provide BCD Data and Overload and Polarity Print signals. Buffer circuits "A" through "P" consist of transistor buffer stages as shown in Figure 14.

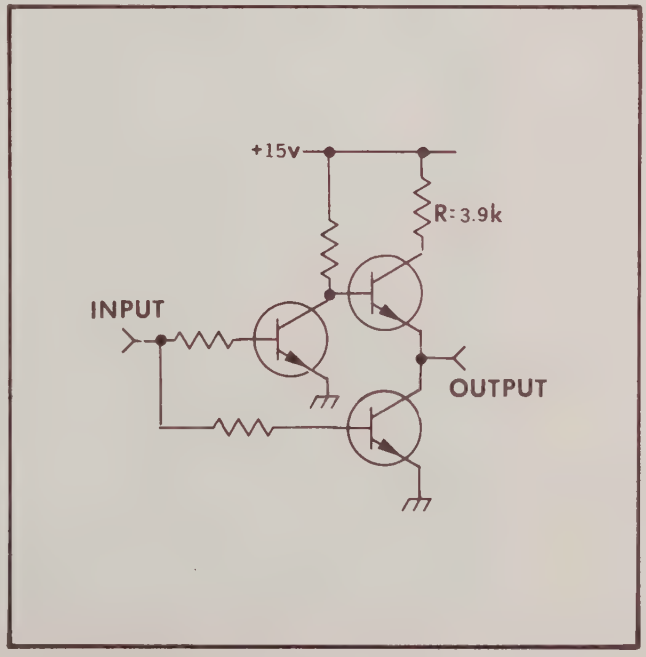


FIGURE 14. Model 4401 Buffer Stage.

h. Output Buffer Board, PC-209. This board contains six buffer circuits and various gate circuits to provide Print Command and Range Signal Print signals.

1. Buffer Circuits. Buffer circuits "A" through "E" provide BCD Range information.

2. Print Command Circuits. Buffer circuits composed of transistors Q1101, Q1102, Q1104, Q1105, Q1106, and Q1107 provide Print Command signals as determined by gates QA1101 (A, B, C, and D) and QA1102 (A, B, C, and D).

3. Range Signal Circuit. Transistors Q1108, Q 1109, and Q1110 comprise a Range Signal Buffer stage controlled by the Range Signal.

4. Reference Voltages. A High and Low Reference voltage is provided by resistor divider R1114, R1115, and R1116. The voltages are +8 volts (High) and +2 volts (Low).

3-6. POWER SUPPLIES (Schematic 23448E).

a. ± 15 Volt Supply. The ±15 volt supplies tap ac power from a secondary of transformer T101. Diodes D103, D105, D107 and D108 and capacitors C104 and C105 compose a full-wave rectifier with filtering. Transistors Q114 and Q115 form a differential amplifier which compares the voltage at R115 with the voltage of zener diode D110. The difference voltage is amplified by transistor Q109 and fed to Darlington transistor pair, Q106 and Q107, which series regulate the output voltage. Transistors Q116 and Q117 form a differential amplifier which compares the voltage at R123 with respect to lo. The difference voltage is amplified by transistor Q113 and fed to Darlington transistor pair, Q110 and Q111, which series regulate the -15 volt output. Transistors Q108 and Q112 limit the output current to about 200 milliamperes.

b. +3.6 Volt Supply. The +3.6 volt supply taps ac power from a secondary of transformer T101. Diodes D101 and D102 and capacitor C101 form a full-wave rectifier with filtering. Transistor Q105 amplifies the difference between the +3.6 volt output and a reference voltage derived from the +15 volt supply and determined by resistors R103 and R104. The difference voltage is amplified by transistor Q104 which drives a Darlington transistor pair, Q101 and Q102. The Darlington pair series regulates the +3.6 volt output. Transistor Q103 limits the output current to about 3 amperes.

c. +170 Volt Supply. The +170 volt supply taps ac power from a secondary of transformer T101. Diode D111 and capacitor C112 form a half-wave rectifier with filtering. Transistor Q119 amplifies the voltage developed by the resistor divider R128 and R129. The output of Q119 controls the series regulator transistor Q118 to maintain the +170 volt output. When the electrometer is overloaded, and overload signal drives transistor Q120 which in turn controls the voltage at the base of transistor Q119. The circuit composed of diode D112, transistor Q120, and resistors R130, R131, and R132 reduces the +170 volt output to +80 volts when overloading occurs. Grounding the overload input turns off transistor Q120 causing diode D112 to conduct the drive Q119. The reduced +80 volt output causes blanking on all Numerical Readout Tubes connected to the +170 volt supply.

d. +210 Volt Output. The +210 volt supply is an unregulated voltage supply using the half-wave filtered voltage at diode D111 and capacitor C112.

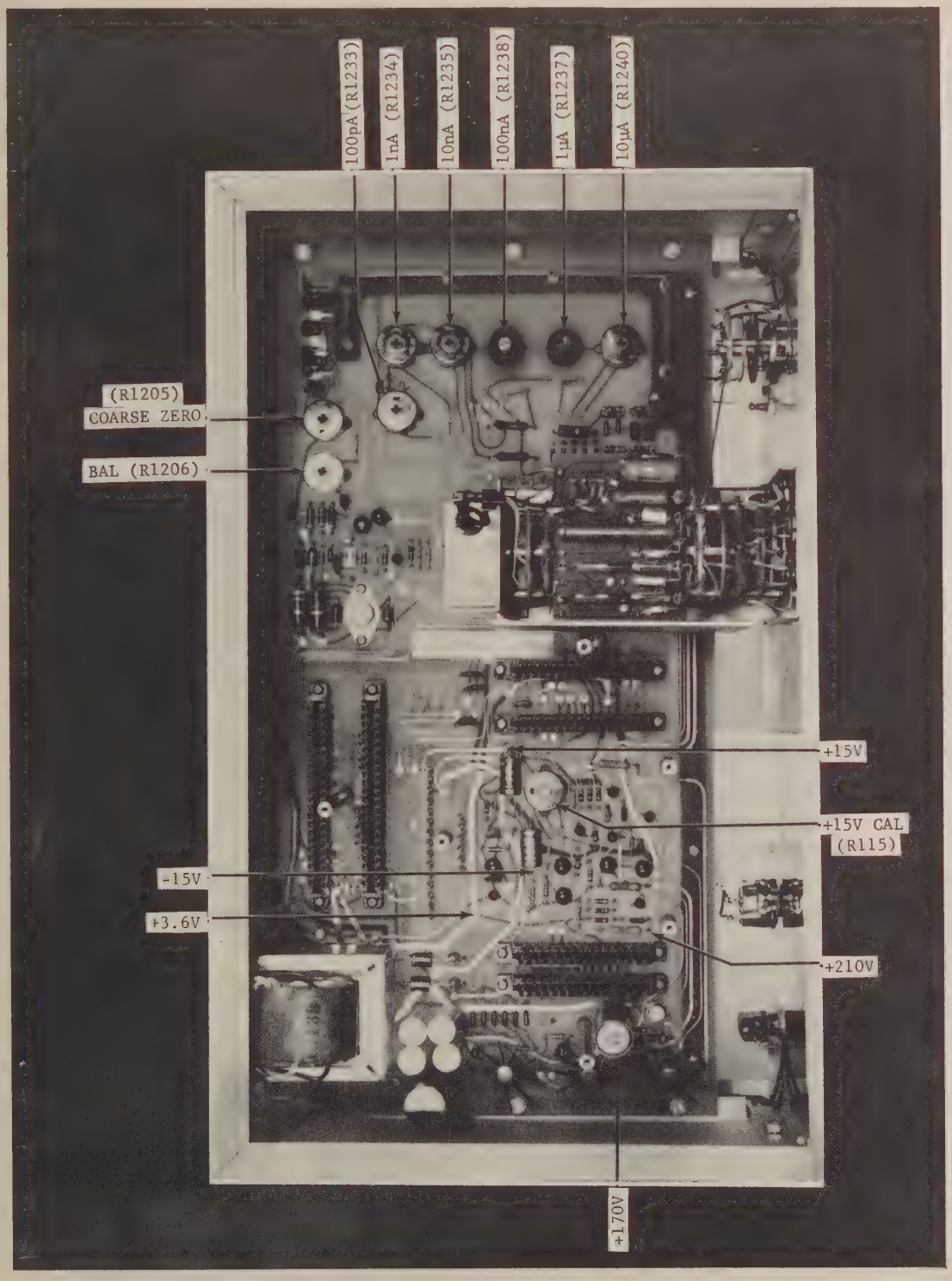


FIGURE 15. Chassis Top View, Showing Cal. Adjustments.

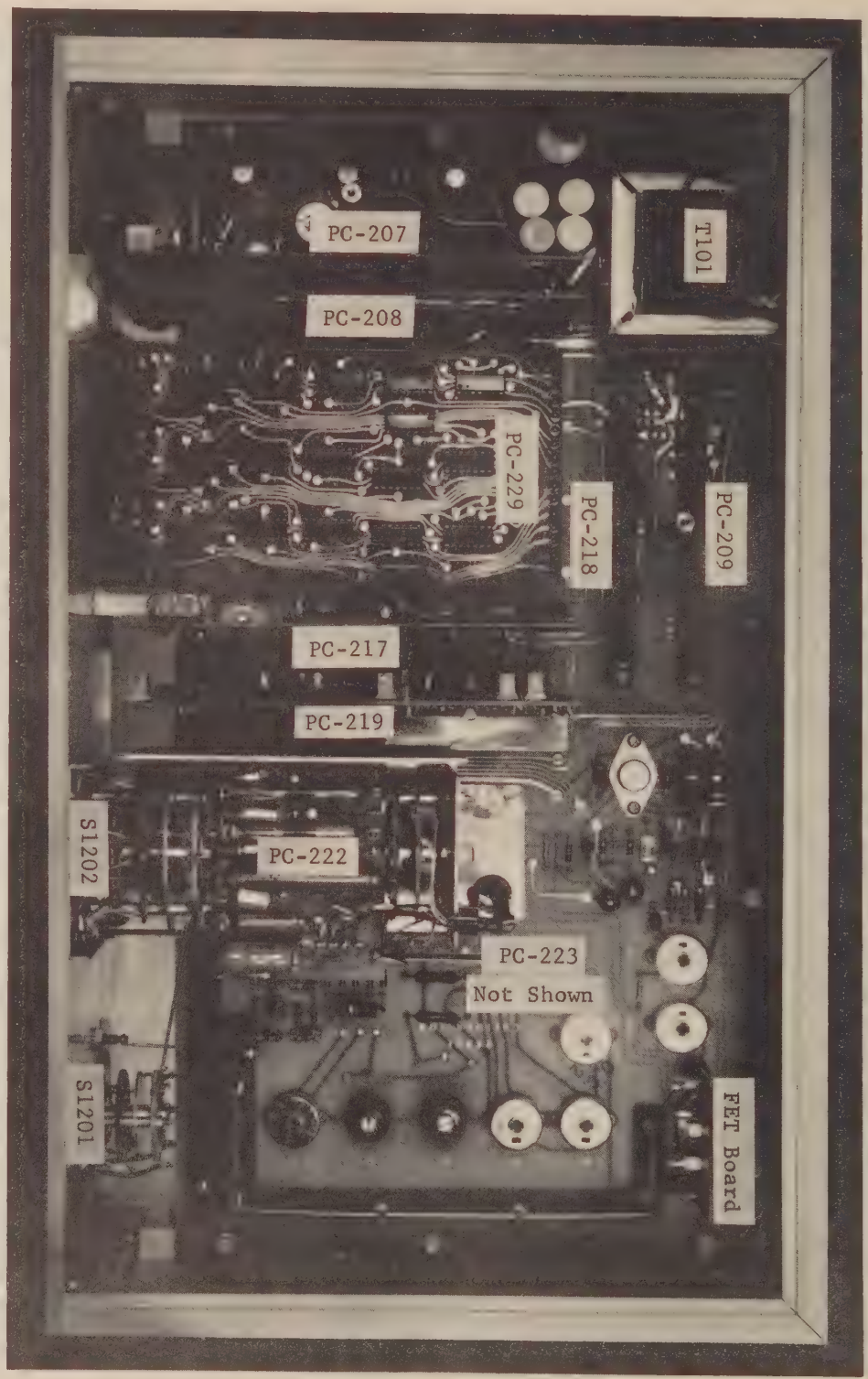


FIGURE 16. Location of Printed Circuit Boards.

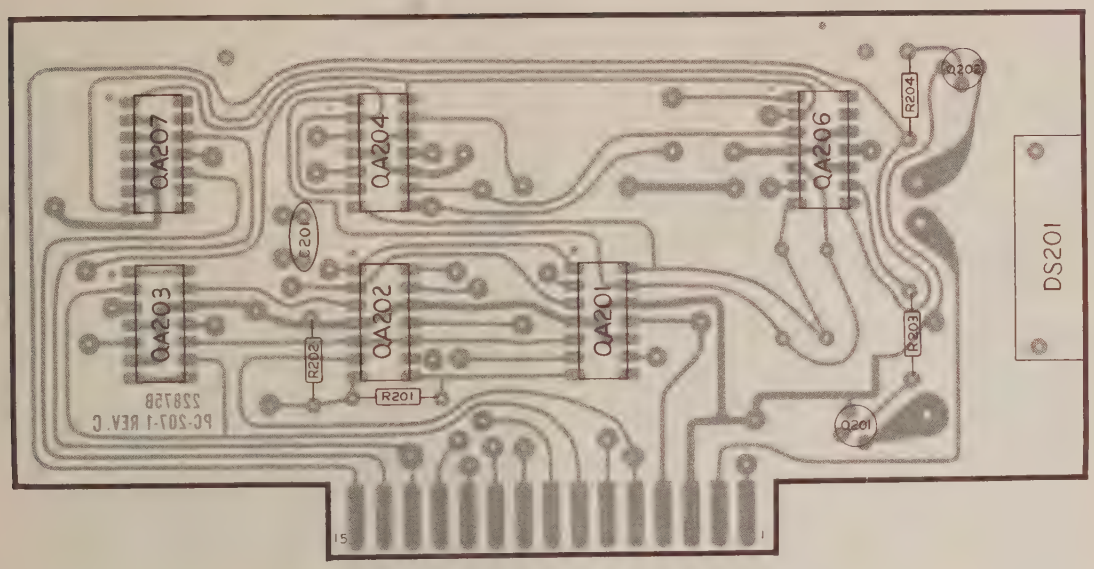


FIGURE 17. Component Layout, PC-207.

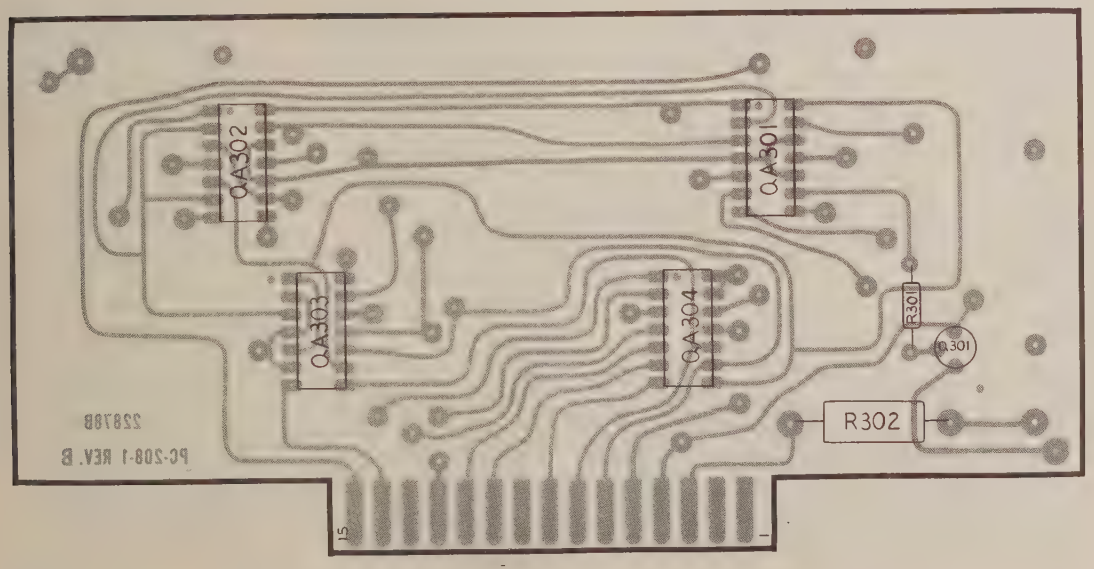


FIGURE 18. Component Layout, PC-208.

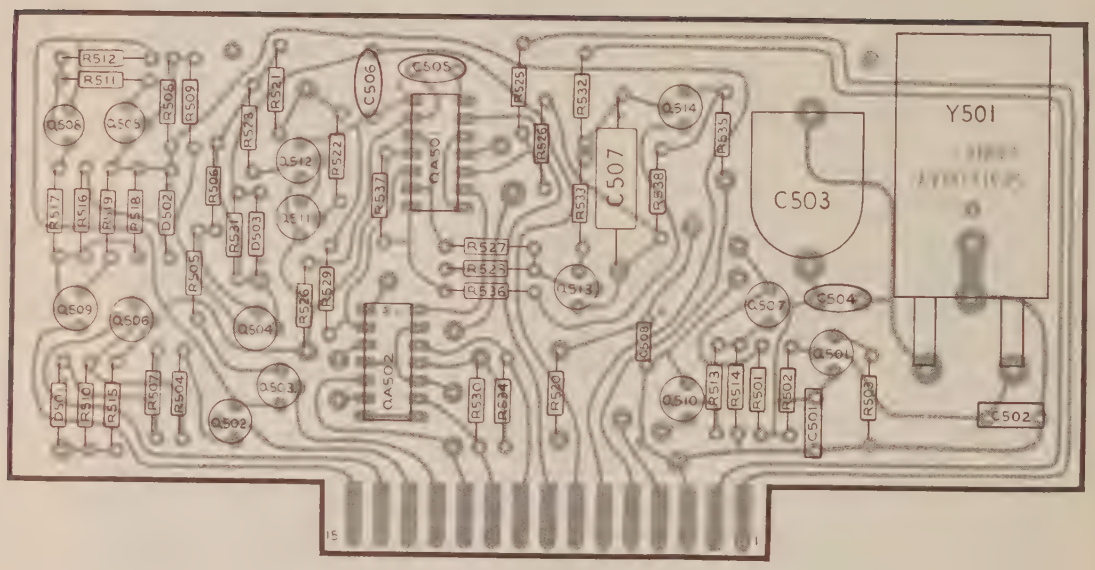


FIGURE 20. Component Layout, PC-217.

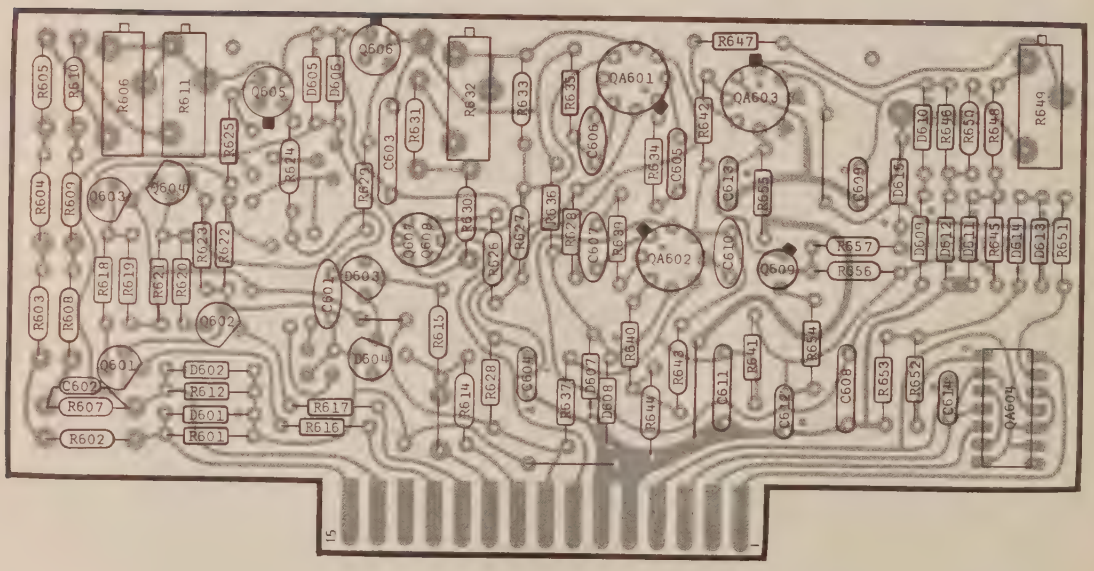
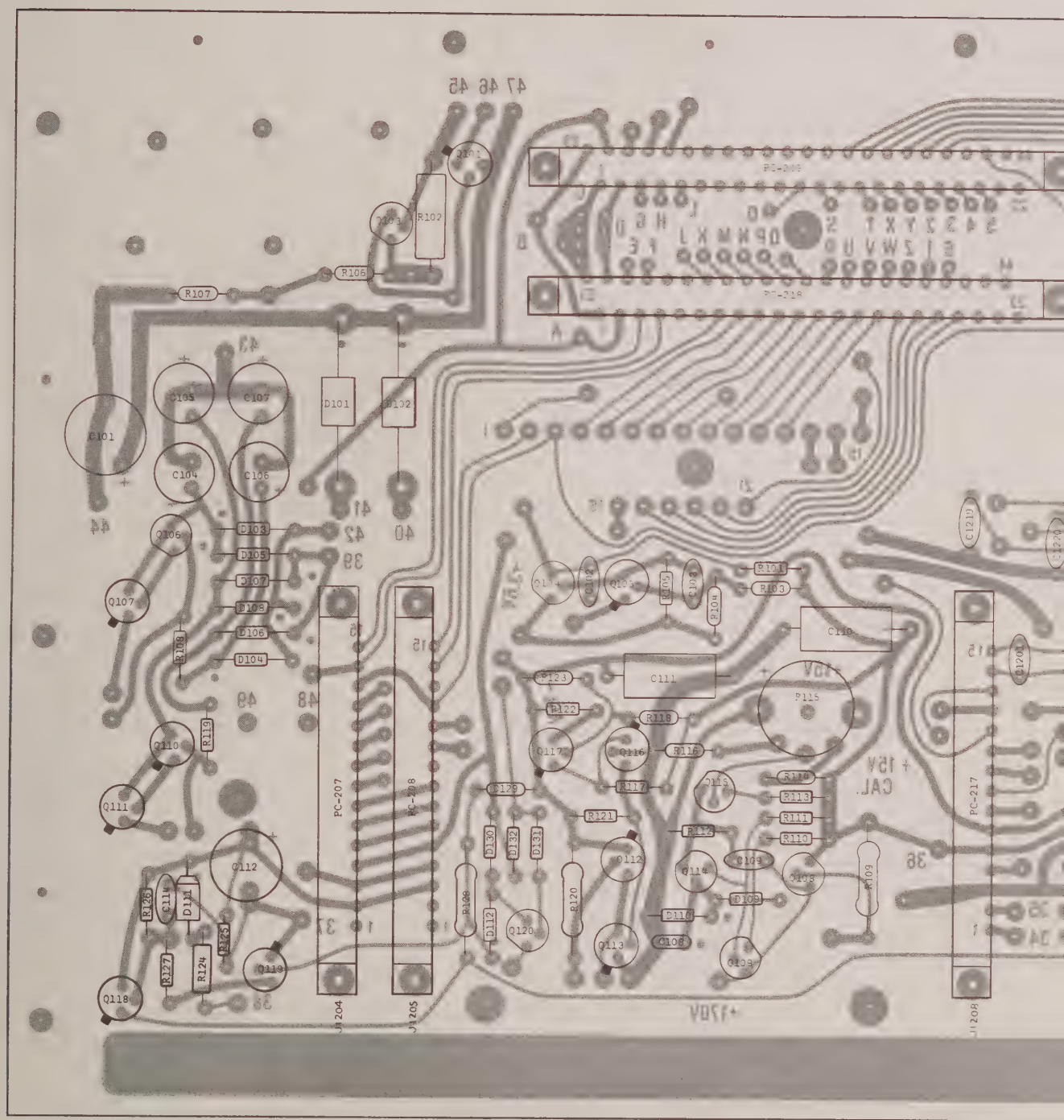
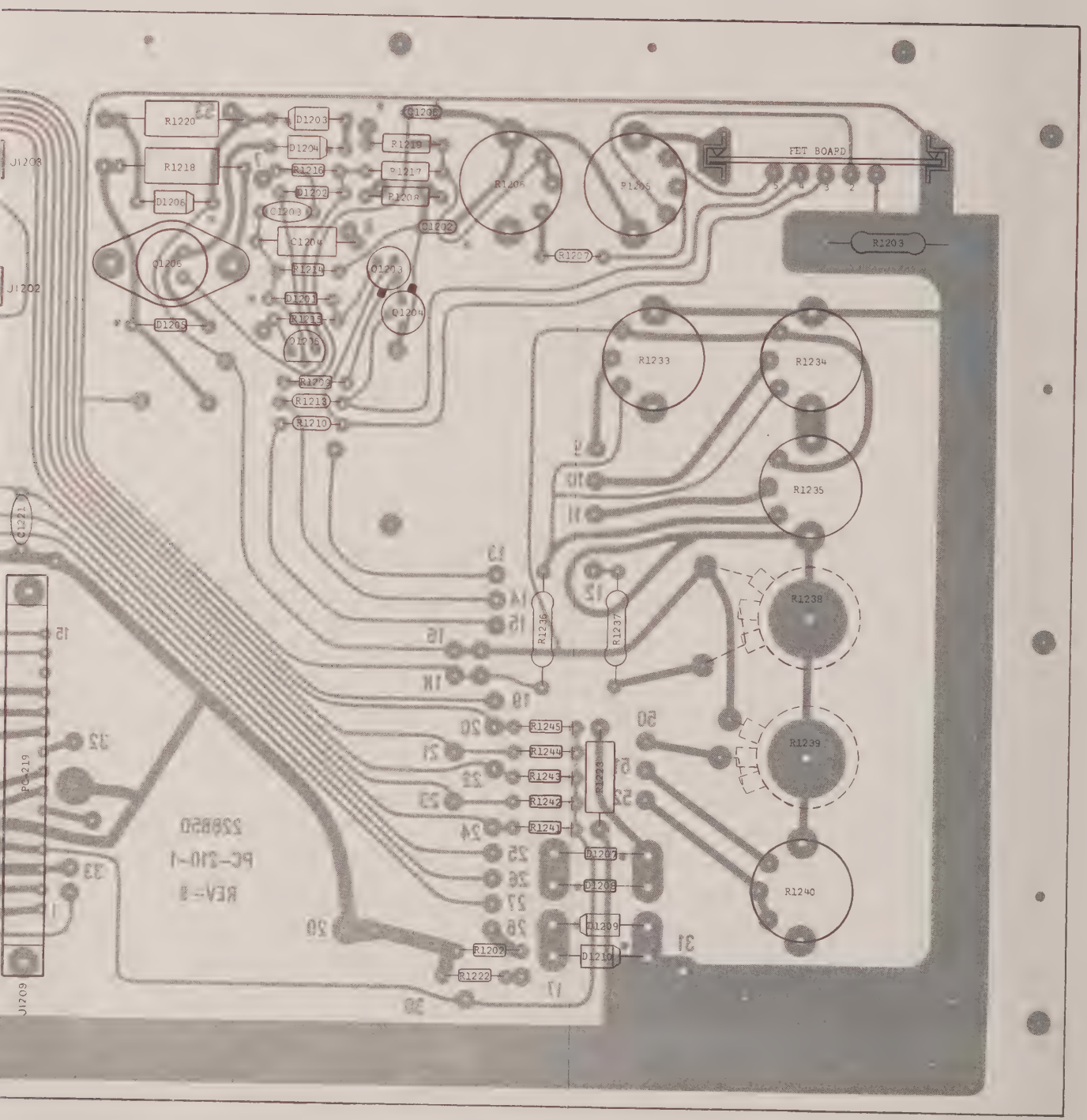


FIGURE 21. Component Layout, PC-219.


PC-207
PC-208
PC-217
C101
C103
C104
C106
C107
C110
C111
D101
D102
D103
D104
D105
D106
D107
D108
R102
R105
R107
R108
R109
R110
R111
R113
R116
R117
R118
R119
R120
R121
R122
R123
R124
R125
R126
R127
Q101
Q102
Q103
Q104
Q105
Q106
Q107
Q108
Q109
Q110
Q111
Q112
Q113
Q114
Q115
Q116
Q117
Q118
Q119
Q120
P115
J204
J205
J208
+15V CAL.


FET BOARD
R1220
R1218
D1206
D1203
D1204
D1216
D1202
D1205
C1204
R1214
D1201
R1213
D1215
R1212
R1213
R1210
Q1206
Q1203
Q1204
Q1205
R1205
R1206
R1207
R1203
R1233
R1234
R1235
R1238
R1239
R1240
R1236
R1237
R1245
R1244
R1243
R1242
R1241
R1208
D1207
D1208
D1209
D1210
R1202
R1222
J1208
J1202
J1209
PC-219
PC-210-1
REV-3

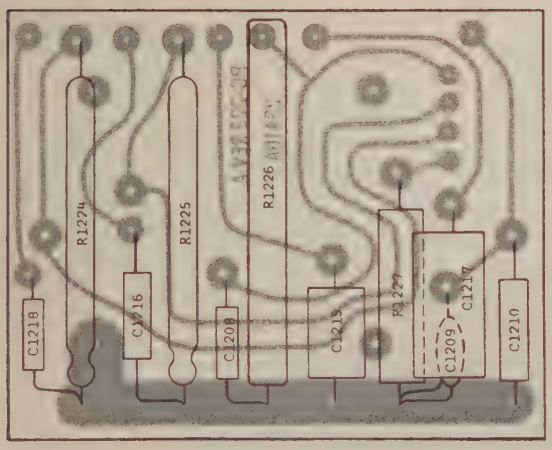


FIGURE 22. Component Layout, PC-222.

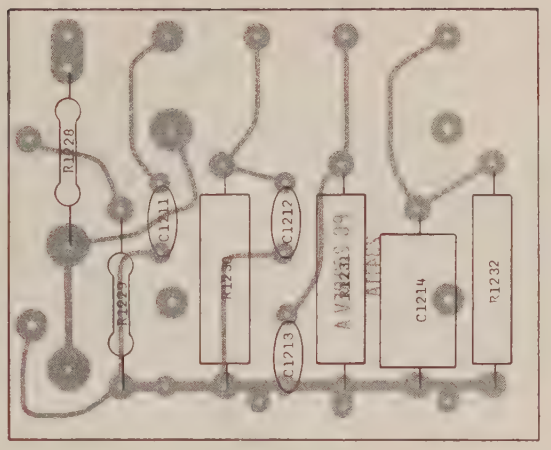


FIGURE 23. Component Layout, PC-223.

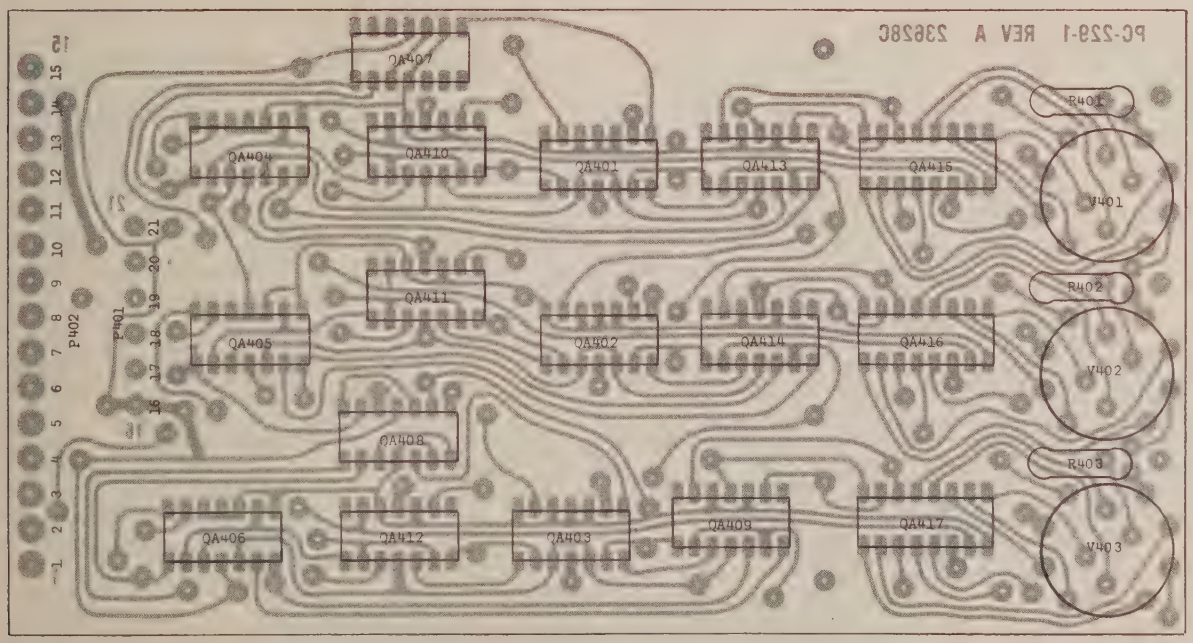


FIGURE 24. Component Layout, PC-229.

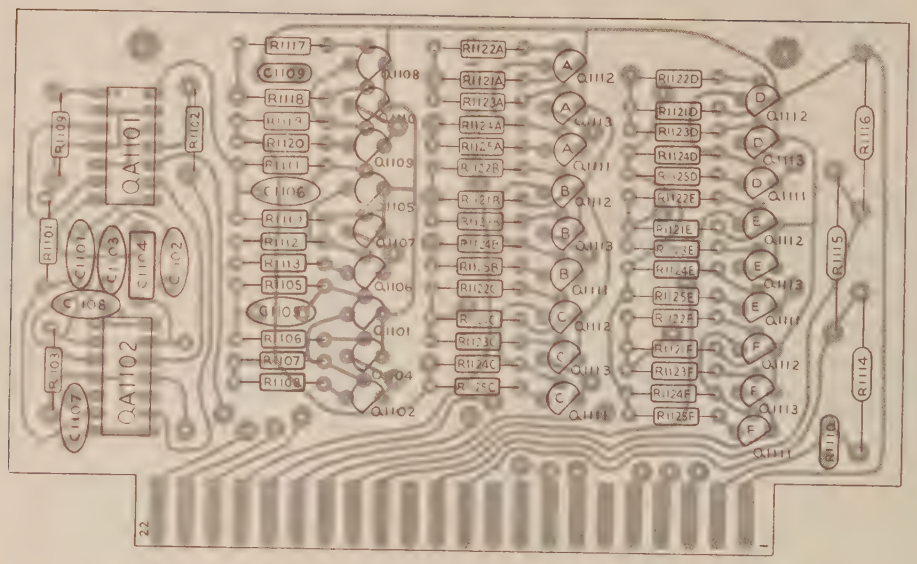


FIGURE 25. Component Layout, PC-209.

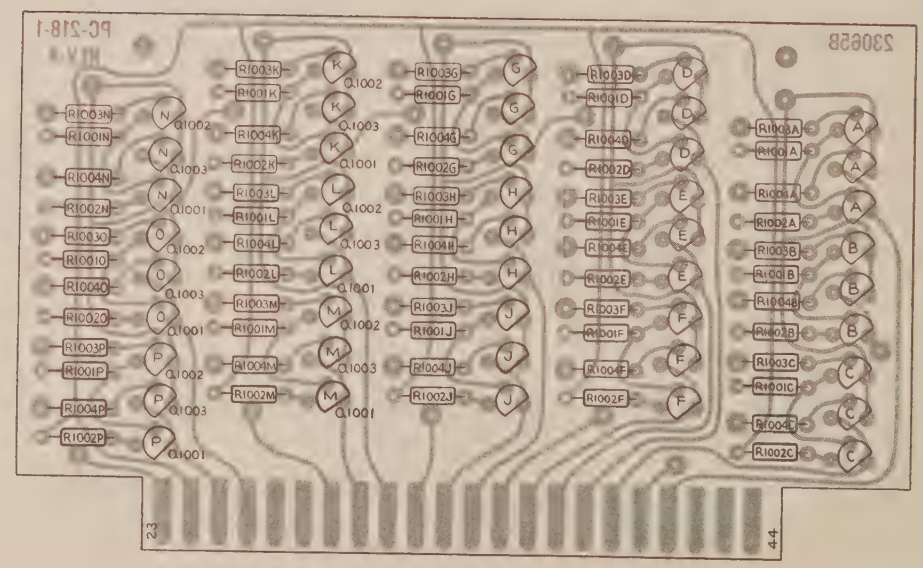


FIGURE 26. Component Layout, PC-218.

SECTION 4. ACCESSORIES

Model 4401 Printer Output Cards

Description: The Model 4401 consists of two printer output cards which may be installed at the factory or in the field since no wiring is required. The output cards plug into prewired connectors on the chassis. BCD outputs are provided through the use of a 50-pin prewired output connector.

Model 4405 Terminal Box

Description: The Model 4405 consists of a 50-terminal box with convenient barrier-strip connections and a 3 ft. cable terminated with a CS-220 connector.

Model SC51 Fifty-Conductor Cable

Description: The Model SC51 cable is useful for fabricating a custom-length cable for use with the Model 4401 Printer Output cards. The cable is sold in custom lengths on special order.

Model 4406 Extender Cards

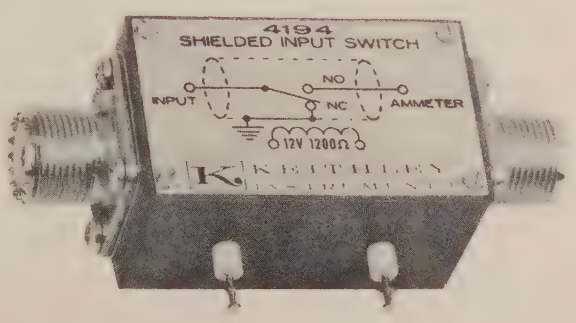
Description: The Model 4406 consists of two extender cards and one extractor for pulling pc cards. The extender cards permit access to test points and calibration controls on cards having either 15 or 22 pins.

Parts List:

Description	Keithley Part No.
PC Card Extractor	4195
PC Card Extender	(22 pins) PC-225
PC Card Extender	(15 pins) PC-224

Model 4194 Shielded Input Switch

Description: The Model 4194 is a remotely controlled reed switch that permits shorting of the input during sample changes, etc. The switch is useful in automated testing where it is important to keep the source input shorted when not being measured.



Model 3001 Bench Mounting Kit

Description:

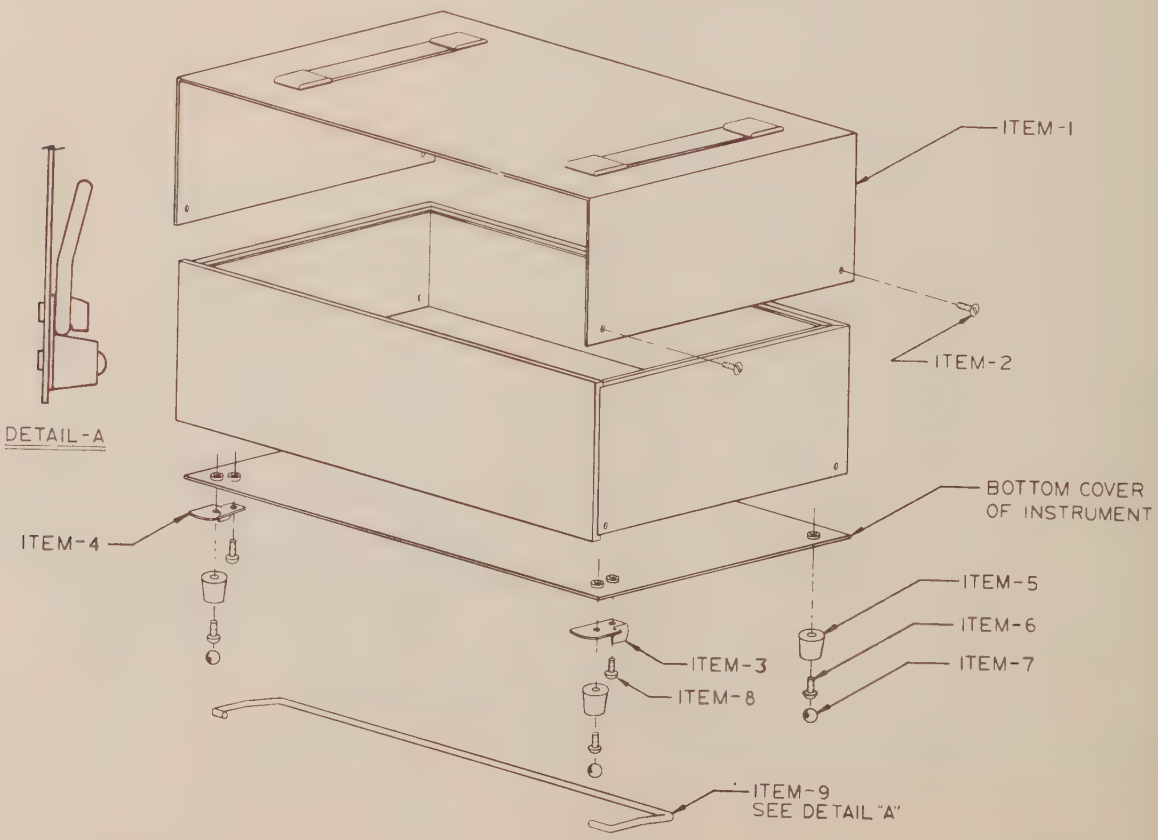
The Model 3001 is a bench mounting kit for use with instruments 5-1/4" high x 17-1/2" wide x 10" deep. All parts are included for conversion of a rack mounted instrument to bench mounting complete with top cover, handle assembly, non-skid feet and tilt bail assembly.

Parts List:

Item No.	Description	Qty. Per Assembly	Keithley Part No.
1	Cover Assembly	1	17604B
2	Screw, Slotted 10-32x1/4	4	-
3	Bail Support, Right	1	19206B
4	Bail Support, Left	1	19205B
5	Foot, plastic	4	FE-5
6	Screw, Phillips, 8-32x3/8	4	-
7	Rubber Foot Insert	4	FE-6
8	Screw, Phillips, 6-32x1/4	2	-
9	Tilt Bail	1	14704B

Assembly:

1. Remove the rack angles attached to the rack mounted instrument. The four 10-32 slotted screws supplied with the instrument should be used to install the bench-style top cover (item 1).
2. Remove the bottom cover to facilitate the mounting of the non-skid feet and tilt bail assembly. Use a screw driver to turn the pawl-type fasteners on the cover (about one-half turn clockwise).
3. Install the bail supports (items 3 and 4) using 6-32 screws (item 8).
4. Install the plastic feet (item 5) using 8-32 screws (item 6) in four places.
5. Install tilt bail (item 9) as shown.
6. Install bottom cover using pawl-type fasteners.



SECTION 5. CALIBRATION

5-1. GENERAL. This section contains information necessary to calibrate the instrument.

5-2. REQUIRED TEST EQUIPMENT. Recommended test equipment for checking and adjusting the instrument is given in Table 5-1.

5-3. ADJUSTMENT/CALIBRATION PROCEDURE.

NOTE 1.

To obtain rated accuracy, perform calibration at the ambient temperature of end use area, otherwise temperature coefficient correction factors must be used (See Specifications). During calibration, the ambient temperature should be constant within ±1°C. Relative humidity should be within range from 20 to 60%.

NOTE 2.

The top and bottom covers should be installed for A/D Converter and Picoammeter calibration. It is recommended that special punched top and bottom covers be fabricated. See Figures 30 and 31 for templates for covers. Alternately, the top cover may be removed for short periods of time. After adjustment, replace cover and allow instrument to stabilize for a few minutes before the cal. procedure is continued.

NOTE 3.

Care must be taken to minimize stray noise during calibration. Current sources should be isolated (floating) from ground. Model 440 should be grounded. DVM should be isolated.

a. Power Supply Adjustment. (Top and bottom covers must be removed for this adjustment).

1. Set LINE Switch to 117V or 234V if higher line voltage is only available. (Switch S101.)

2. Connect line voltage of 115V ±3 volts, or 234V ±6 volts, 60 Hz (or 50 Hz, see note).

NOTE

If instrument is 50 Hz version, oscillator circuit should have 100kHz crystal installed on PC-217. (Y501, Keithley Part No. CR-2.)

3. Turn on Power (Switch S102).

4. Remove bottom cover and measure dc voltage at +15V test point on mother board on tape side of PC-210 using DVM (C).

5. Adjust potentiometer R115 for +15.000 ±50mV.

6. Check remaining regulated voltages as shown in Table 5-2.

TABLE 5-1.
Recommended Test Equipment for Calibration.

Item	Minimum Performance Required	Mfr.	Model
A	Current Source, Ranges: Variable around 200nA	Keithley	261
B	Current Source, Ranges: ±10mA to ±10pA Accuracy: ±0.02%, from 10mA to 100µA ±0.05%, from 10µA to 1µA ±0.2%, 100nA ±0.3%, from 10nA to 100pA ±0.5%, 10pA (Source must have output capacitance less than 100pF) (Positive and negative tracking must be within one-half the max. tolerance.)		
C	Digital Voltmeter (DVM), 5-1/2 digits, ±10 microvolts to ±20V. Accuracy: ±0.02% of reading.	Keithley	190
D	Digital Counter, 100kHz or 120kHz ±1 Hz.	Eldorado	1507B
E	Oscilloscope (mainframe) Amplifier Plug-in, 1mV/Div, DC to 500kHz Time-Base Plug-in, 5ms/Div	Tektronix Tektronix Tektronix	561B 3A9 2B67
F	Null Detector, ±10µV to ±10V, ±2% accuracy, $10^{12}\Omega$ isolation	Keithley	155

TABLE 5-2.
Power Supply Voltage Verification.

Voltage	Test Point	Tolerance
+15.000V	+15V	±50mV
-15.000V	-15V	±0.4V
+3.6V	+3.6V	±0.1V

b. Zero Adjust. (Top cover must be removed for these adjustments.)

1. Set front panel Zero Adjust (R1211) to mechanical center of adjustment span.

2. Set Display Rate to MAX.

3. Set Range to 10mA.

4. Select ZERO CHECK, with no input signal connected.

5. Set Damping to Min.

6. Connect Null Detector (F) to Model 440 ANALOG OUTPUT (J1213).

7. Connect DVM (must be floating) across resistor R1210 (18.2kΩ).

8. Adjust Coarse Zero (R1205) for 0 ± 2 millivolts at ANALOG OUTPUT (J1213).

9. Adjust Balance (R1206) for 5.2V ± 0.1V.

10. Repeat steps 8 through 9 until both readings are obtained simultaneously.

11. With Null Detector (F) connected, adjust front panel Zero Adjust (R1211) for 0 ± 0.1mV at ANALOG OUTPUT (J1213).

c. Clock Adjust. (Top cover must be removed for this adjustment.)

1. Set Display Rate to MAX.

2. Connect Counter (D) between "CLOCK" test point on printed circuit board PC-217 and "GND" test point on PC-219.

3. Adjust Frequency Adjust (C503) on PC-217 for a Counter reading of 120kHz ± 1 Hz. (If Model 440 is 50 Hz version, set frequency for 100kHz ± 1 Hz.)

NOTE

Capacitor C504 (22pF) may be added or removed to extend the adjustment range of trimmer C503.

d. Stabilization. Top/Bottom covers are installed. With power on, allow the Model 440 to stabilize in the calibration area for two hours.

e. Picoammeter Range Calibration.

IMPORTANT

Care must be exercised so as to avoid overloads on any range during calibration. The Damping control may be used to reduce the output noise on ranges 100pA to 100nA if necessary.

1. Set Display Rate to MAX.

2. Select 100pA range.

3. Select ZERO CHECK.

4. Connect DVM to ANALOG OUTPUT of Model 440.

5. Verify output of 0 ± 0.1mV (adjust front panel zero (R1211) as needed.

6. Connect Current Source to Model 440 INPUT (J1210).

7. Apply +100pA.

8. Adjust 100pA Cal. (R1233) to obtain -1.0000V ± 0.1mV at ANALOG OUTPUT (J1213).

9. Complete remainder of current range calibration in accord with Table 5-3.

f. A/D Zero Adjustment.

1. Set Display Rate at MAX.

2. Connect Oscilloscope as shown in Figure 27.

3. Connect DVM to ANALOG OUTPUT (J1213) of Model 440.

4. Set range to 100nA and HOLD.

5. Place Model 440 in ZERO CHECK.

6. Adjust front panel Zero Adjust (R1211) for 0 ± 0.1mV at ANALOG OUTPUT (J1213).

7. Set Oscilloscope to following:

a). With INTEGRATOR test point connected to vertical input, set vertical gain to 5mV/div., dc coupled.

b). With EXT. TRIGGER test point connected to horizontal input, set horizontal gain to 5ms/div., ac coupled.

c). Set trigger to EXT, +.

8. Adjust INTEGRATOR ZERO (R632) to minimize wave-form amplitude as shown in Figure 28.

9. Adjust ZERO CROSSING ADJ. (R649) to minimize wave-form amplitude as shown in Figure 28. Increase Oscilloscope vertical sensitivity as necessary (to 1mV/div, dc coupled).

TABLE 5-3.
Current Range Accuracy Calibration.

Range	Input	Output Reading	Adjustment/Verification
100pA*	Zero Check	0 ± 0.1mV	Verify
	+100pA	-1V ± 0.1mV	Adjust 100pA CAL. (R1233)
	-100pA	+1V ± 0.3%	Verify
	+10pA	-0.1V ± 0.8%	Verify
	-10pA	+0.1V ± 0.8%	Verify
1nA	Zero Check	0 ± 0.1mV	Verify
	+1nA	-1V ± 0.1mV	Adjust 1nA CAL. (R1234)
	-1nA	+1V ± 0.3%	Verify
	+100pA	-0.1V ± 0.6%	Verify
	-100pA	+0.1V ± 0.6%	Verify
10nA	Zero Check	0 ± 0.1mV	Verify
	+10nA	-1V ± 0.1mV	Adjust 10nA CAL. (R1235)
	-10nA	+1V ± 0.3%	Verify
	-1nA	-0.1V ± 0.6%	Verify
	+1nA	+0.1V ± 0.6%	Verify
100nA	Zero Check	0 ± 0.1mV	Verify
	+100nA	-1V ± 0.1mV	Adjust 100nA CAL. (R1238)
	-100nA	+1V ± 0.2%	Verify
	+10nA	-0.1V ± 0.5%	Verify
	-10nA	+0.1V ± 0.5%	Verify
1µA	Zero Check	0 ± 0.1mV	Verify
	+1µA	-1V ± 0.1mV	Adjust 1µA CAL. (R1239)
	-1µA	+1V ± 0.06%	Verify
	+100nA	-0.1V ± 0.25%	Verify
	-100nA	+0.1V ± 0.25%	Verify
10µA	Zero Check	0 ± 0.1mV	Verify
	+10µA	-1V ± 0.1mV	Adjust 10µA CAL. (R1240)
	-10µA	+1V ± 0.06%	Verify
100µA	Zero Check	0 ± 0.1mV	Verify
	+100µA	-1V ± 0.2%	Verify
	-100µA	+1V ± 0.2%	Verify
1mA	Zero Check	0 ± 0.1mV	Verify
	+1mA	-1V ± 0.2%	Verify
	-1mA	+1V ± 0.2%	Verify
10mA	Zero Check	0 ± 0.1mV	Verify
	+10mA	-1V ± 0.1mV	Verify
	-10mA	+1V ± 0.03%	Verify

*If calibration of 100pA range is not possible, the problem may be a result of excessive offset current (less than $\pm 2 \times 10^{-14}$A at factory calibration).

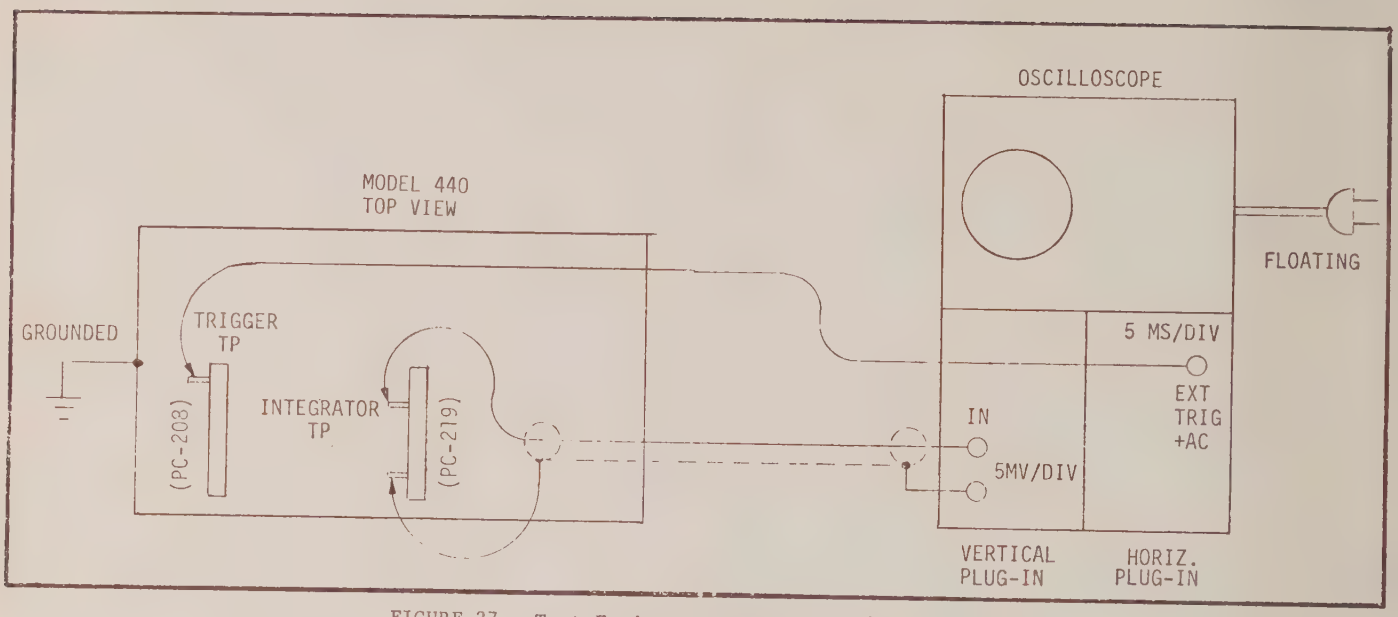


FIGURE 27. Test Equipment Set-up for A/D Calibration.

NOTE

If range of adjustment of INTEGRATOR ZERO (R632) is insufficient add or remove jumpers across resistors R630 and R631.

10. Set vertical oscilloscope input to GND (using AC/DC/GND switch) to set reference "0" position. Switch to DC and verify that RESET position coincides with "0".

11. With RESET adjusted on oscilloscope grid line, adjust INTEGRATOR ZERO to set "Integrator" waveform within ±0.1mV of RESET position.

12. Adjust ZERO CROSSING ADJ. (R649) to obtain a zero reading on the Model 440 display such that the polarity indicator flashes + and -.

13. Remove Oscilloscope and other leads from Model 440.

g. A/D Linearity Adjust.

1. Connect Current Source (A) to Model 440 INPUT.

2. Open ZERO CHECK.

3. Apply a positive input current to Model 440.

4. Adjust Current Source and front panel zero as necessary for ANALOG OUTPUT reading of -1.9995V ± 0.1mV.

5. Adjust + REF. Control (R611, PC-219) for a Model 440 display flashing between +1.999 and blank.

NOTE

Add or remove jumper wires which shunt resistors R608, R609 or R610 (on printed circuit board PC-219) to extend the range of adjustment on potentiometer R611. Resistor R607 may be changed if necessary.

6. Apply a minus input current to Model 440.

7. Adjust Current Source and front panel zero as necessary for ANALOG OUTPUT reading of -1.9995V ± 0.1mV.

8. Adjust - REF. Control (R606, PC-219) for a Model 440 display flashing between -1.999 and blank.

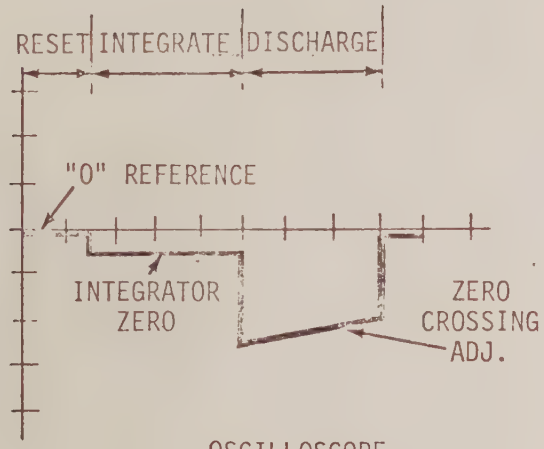
NOTE

Add or remove jumper wires which shunt resistors R603, R604, or R605 (on printed circuit board PC-219) to extend the range of adjustment on potentiometer R606. Resistor R602 may be changed if necessary.

9. Place Model 440 in ZERO CHECK.

10. Adjust front panel Zero Control for ANALOG OUTPUT of 0 ± 0.1mV.

11. Model 440 display should indicate ±000.



OSCILLOSCOPE SETTINGS

VERT - 1mV/DIV
HORIZ - 5MS/DIV
SYNC - + EXT TRIG

FIGURE 28. A/D Converter Zero Adjustments.

SECTION 6. REPLACEABLE PARTS

6-1. REPLACEABLE PARTS LIST: This section contains a list of components used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufacturer's Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of each Manufacturer is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 6-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
		Fig	Figure		
CbVar	Carbon Variable			p	pico (10^{-12})
CerD	Ceramic Disc	GCb	Glass enclosed Carbon	PC	Printed Circuit
Cer Trimmer	Ceramic Trimmer			Poly	Polystyrene
Comp	Composition	k	kilo (10^{3})		
				Ref.	Reference
DCb	Deposited Carbon	μ	micro (10^{-6})		
Desig.	Designation			TCu	Tinner Copperweld
		M	Meg (10^{6})		
EAL	Electrolytic, Aluminum	Mfr.	Manufacturer	V	volt
ETB	Electrolytic, tubular	MtF	Metal Film		
ETT	Electrolytic, tantalum	My	Mylar	W	watt
				WW	Wirewound
		No.	Number	WWVar	Wirewound Variable

6-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as discussed in Section 3. Table 6-2 identifies all schematic part numbers included.

6-3 HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. Main Chassis parts are listed followed by printed circuit boards and other subassemblies.

6-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

1. Instrument Model Number.
2. Instrument Serial Number.
3. Part Description.
4. Schematic Circuit Designation.
5. Keithley Part Number.

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 6-2.

Description	Circuit Description	Schematic Part No.
Main Chassis	PC-210	23482E
Power Supply	PC-210	23448E
Polarity Board	PC-207	23449D
Thousand Board	PC-208	23450D
Readout Board	PC-229	23451E
Oscillator Board	PC-217	23452D
Integrator Board	PC-219	23453E
Output Buffer	PC-218	23457D
Output Buffer	PC-209	23481E
Basing Diagram	-	23606D

TABLE 6-3.
Mechanical Parts List.

Item No.	Description	Quantity Per Assembly	Keithley Part No.
1	Top Cover Assembly	-	17958C
-	Cover	1	17162C
-	Fastener	2	FA-54
2	Bottom Cover Assembly	-	17960C
-	Cover	1	17957C
-	Fastener	2	FA-54
3	Angle, Rack Assembly	2	14624B
4	Screw, Slotted, 10 - 32 x 1/4	4	-
5	Front Panel	1	23026D
6	Chassis	1	23039B

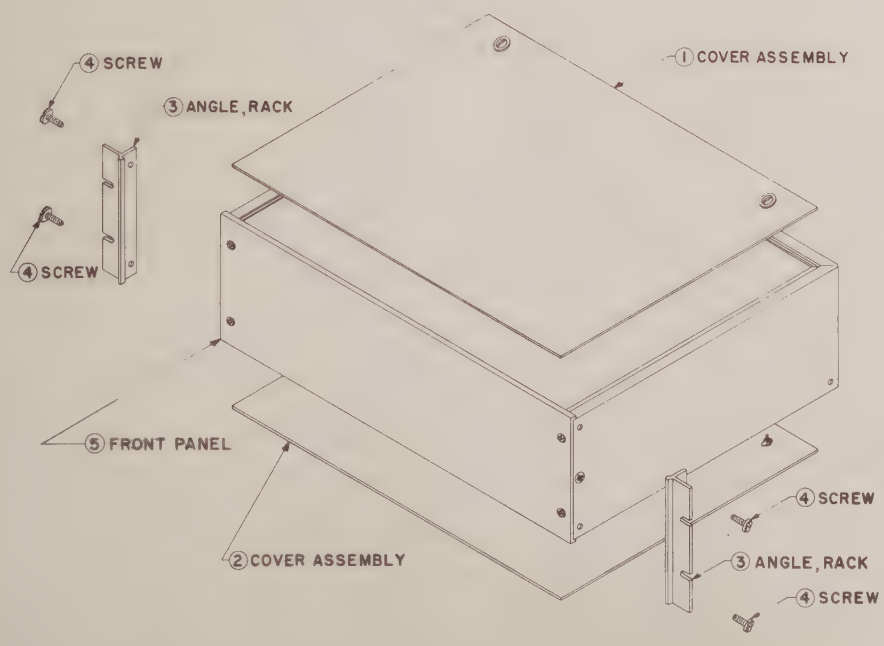


FIGURE 29. Mechanical Assembly.

TABLE 6-4.
PC Board Designation Series

Series	Description	Designation	Connector	Page No.
100	Power Supply	PC-210	-	38
200	Polarity Board	PC-207	J1204	40
300	Thousand Board	PC-208	J1205	41
400	Readout Board	PC-229	J1206/J1207	41
500	Oscillator Board	PC-217	J1208	42
600	Integrator Board	PC-219	J1209	44
1000	Output Buffer Board	PC-218	J1202	46
1100	Output Buffer Board	PC-209	J1213	47
1200	Main Chassis	PC-210	-	35

MAIN CHASSIS PARTS LIST
("1200" Series, PC-210)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C1201	5 pF	600 V	CerD	72982	ED-5	C22-5P	19
C1202	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	19
C1203	.0047 µF	600 V	CerD	72982	ED-.0047	C22-.0047M	19
C1204	.047 µF	200 V	My	13050	SM1A	C143-.047M	19
C1205	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	19
C1206	Not Used						
C1207	Not Used						
C1208	47 pF	500 V	Poly	71590	CPR-47J	C138-47P	19
C1209	220 pF	600 V	CerD	72982	ED-220	C22-220P	19
C1210	.001 µF	500 V	Poly	71590	CPR-.001J	C138-.001M	19
C1211	.01 µF	600 V	CerD	72982	ED-.01	C22-.01M	19
C1212	.02 µF	600 V	CerD	72982	ED-.02	C22-.02M	19
C1213	.02 µF	600 V	CerD	72982	ED-.02	C22-.02M	19
C1214	.25 µF	400 V	My	13050	SM1A	C73-.25M	19
C1215	5000 pF	500 V	Poly	71590	CPR-5000J	C138-5000P	19
C1216	510 pF	500 V	Poly	71590	CPR-510J	C138-510P	19
C1217	.05 µF	600 V	My	56289	6PS-550	C62-.05M	19
C1218	47 pF	500 V	Poly	71590	CPR-47J	C138-47P	19
C1219	.0047 µF	600 V	CerD	72982	ED-.0047	C22-.0047M	19
C1220	.0047 µF	600 V	CerD	72982	ED-.0047	C22-.0047M	19
C1221	.0047 µF	600 V	CerD	72982	ED-.0047	C22-.0047M	19

CONNECTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
J1201	Plug-in Contacts	91662	02-005-113-6-200	CS-199	19
P1201	Contacts, mate of J1201	91662	02-005-111-5-200	CS-200	-
J1202	Receptacle, 44 pins, front card of Output Buffer Stage PC-218	09922	PSC 4DD22-12	CS-205	19
J1203	Receptacle, 44 pins, Rear card of Output Buffer Stage PC-209	09922	PSC 4DD22-12	CS-205	19
J1204	Receptacle, 15 pins, Polarity Board PC-207	09922	PSC 4SS15-12	CS-175	19
J1205	Receptacle, 15 pins, Thousand Board PC-208	09922	PSC 4SS15-12	CS-175	19
J1206	Receptacle, 6 pins, Readout Board PC-229	73690	02-006-105-6-200	CS-223	19
J1207	Receptacle, 15 pins, Readout Board PC-229	73690	02-015-105-6-200	CS-222	19
J1208	Receptacle, 15 pins, Oscillator Board PC-217	09922	PSC 4SS15-12	CS-175	19
J1209	Receptacle, 15 pins, Integrator Board PC-219	09922	PSC 4SS15-12	CS-175	19
J1210	Receptacle, UHF, INPUT (Mil. No. 50-239A)	91737	6804	CS-64	2
---	Plug, UHF, mate of J1210 (Mil. No. 49190), Supplied	91737	5127	CS-49	-
---	Dust Cap for J1210, Supplied	95760	EC-10	Cap-1	-

MAIN CHASSIS PARTS LIST
"1200" SERIES, PC-210
CONNECTORS (Cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
J1211	Binding Post, G	08811	33-286	BP-15	2
J1212	Receptacle, 50 pins, PRINTER/CONTROL Connector	02660	57-40500-1	CS-221	3
---	Plug, mate of J1212	02770	57-30500-1	CS-220	-
J1213	Receptacle, Microphone, ANALOG OUTPUT	02660	80-PC2F	CS-32	3
---	Plug, mate of J1213, Supplied	02660	80-MC2M	CS-33	-

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D1201	Silicon	01295	1N914	RF-28	19
D1202	Silicon	01295	1N645	RF-14	19
D1203	Silicon	02735	1N3255	RF-17	19
D1204	Silicon	02735	1N3255	RF-17	19
D1205	Zener	84970	VR47	DZ-30	19
D1206	Silicon	02735	1N3255	RF-17	19
D1207	Silicon	02735	1N3255	RF-17	19
D1208	Silicon	02735	1N3255	RF-17	19
D1209	Silicon	01295	1N645	RF-14	19
D1210	Silicon	01295	1N645	RF-14	19

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R1201	500 kΩ	±20%, 1/4 W	CbVar	71450	GC45	RP75-500K	19
R1202	220 Ω	10%, 1/4 W	Comp	44655	RC07	R76-220	19
R1203	10 MΩ	1%, 1/2 W	DCb	91637	DCF-1/2	R12-10M	19
R1204	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	19
R1205	1 kΩ	20%, 2 W	WW	71450	1NS 115	RP50-1K	19
R1206	10 kΩ	20%, 2 W	WW	71450	1NS 115	RP50-10K	19
R1207	15 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-15K	19
R1208	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100	19
R1209	22 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-22K	19
R1210	18.2 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-18.2K	19
R1211	500 Ω	±20%, 2 W	Cermet	71450	551	RP72-500	19
R1212	Not Used						
R1213	18.2 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-18.2K	19
R1214	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	19
R1215	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	19
R1216	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	19
R1217	3.3 kΩ	10%, 1/2 W	Comp	01121	EB	R1-3.3K	19
R1218	100 Ω	10%, 2 W	Comp	01121	HB	R3-100	19
R1219	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100	19
R1220	470 Ω	10%, 2 W	Comp	01121	HB	R3-470	19
R1221	15 kΩ	±30%, 1/3 W	CbVar	71450	GC45	RP78-15K	19
R1222	1.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.8K	19
R1223	560 Ω	10%, 1 W	Comp	01121	GB	R2-560	19
R1224	10^{10} Ω	+3-0%,1/R W	GCb	63060	RX-1	23093A	19
R1225	10^{9} Ω	+3-0%,1/R W	GCb	63060	RX-1	23092A	19

MAIN CHASSIS PARTS LIST
"1200" SERIES, PC-210
RESISTORS (cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R1226	10^8 Ω	1%, 2 W	DCb	91637	DC-2	R14-10^8	19
R1227	10 MΩ	1%, 1 W	DCb	91637	DC-1	R13-10M	19
R1228	1.02 MΩ	1%, 1/2 W	MtF	07716	CEC	R94-1.02M	19
R1229	102 kΩ	1%, 1/2 W	MtF	07712	CEC	R94-102K	19
R1230	10.5 kΩ	0.1%, 1 W	WW	01686	7040	R70-10.5K	19
R1231	1.05 kΩ	0.1%, 1 W	WW	01686	7040	R70-1.05K	19
R1232	105 Ω	0.1%, 1 W	WW	01686	7040	R70-105	19
R1233	1 kΩ	0.1%, 1 W	WW	01686	7040	RP50-1K	19
R1234	1 kΩ	0.1%, 1 W	WW	01686	7040	RP50-1K	19
R1235	1 kΩ	0.1%, 1 W	WW	01686	7040	RP50-1K	19
R1236	3.01 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-3.01K	19
R1237	301 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-301K	19
R1238	500 kΩ	±20%, 1/4 W	CbVar	71450	Type-45	RP73-500K	19
R1239	50 kΩ	±20%, 2 W	Cermet	71450	550	RP74-50K	19
R1240	5 kΩ	20%, 2 W	WW	71450	1NS 115	RP50-5K	19
R1241	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R1242	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R1243	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R1244	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R1245	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19

SWITCHES AND CONTROLS

Circuit Desig.	Description	Mfr. Code	Keithley Part No.	Fig. Ref.
S1201	Rotary Switch, ZERO CHECK	80164	SW-279	2
---	Knob Assembly, Zero Check Switch	80164	14838A	-
S1202	Rotary Switch less components, RANGE	80164	SW-278	2
---	Rotary Switch with components, Range Switch	80164		-
---	Dial Assembly, Range Switch	80164	23037B	-
S1203	Rotary Switch, DAMPING (see also R1221)	71450	RP78-15K	2
---	Knob Assembly, Damping Control	80164	21384A	-
S1204	Rotary Switch, DISPLAY RATE (see also R1201)	71450	RP75-500K	2
---	Knob Assembly, Display Rate Control	80164	21384A	-
---	Screwdriver Adjust, ZERO Control (see R1211)	71450	RP72-500	2

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q1201	80164	**	20933A	19
Q1202	80164	**	20933A	19
Q1203	07263	S17638	TG-33	19
Q1204	07263	S17638	TG-33	19
Q1205	04713	2N3904	TG-47	19
Q1206	71279	ES-5321	TG-54	19

** Transistors Q1201 and Q1202 are matched and should be ordered only as Keithley Part Number 21850B.

POWER SUPPLY PARTS LIST
("100" Series, PC-210)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C101	2000 µF	15 V	EAl		36-750-2000-15C	C93-2000M	19
C102	100 pF	600 V	CerD	72982	ED-100	C22-100P	19
C103	150 pF	600 V	CerD	72982	ED-150	C22-150P	19
C104	200 µF	35 V	EAl	90201	MTV200N35PDN	C177-200M	19
C105	200 µF	35 V	EAl	90201	MTV200N35PDN	C177-200M	19
C106	200 µF	35 V	EAl	90201	MTV200N35PDN	C177-200M	19
C107	200 µF	35 V	EAl	90201	MTV200N35PDN	C177-200M	19
C108	1.2 µF	20 V	ETT	17554	TSD1-20-125	C179-1.2M	19
C109	5 pF	600 V	CerD	72982	ED-5	C22-5P	19
C110	100 µF	15 V	ETB	73445	C426	C3-100M	19
C111	100 µF	15 V	ETB	73445	C426	C3-100M	19
C112	15 µF	300 V	EAl	90201	PTC015-N300-P3E	C173-5M	19
C113	Used on Model 445 only						
C114	68 pF	500 V	MICA	84171	DM15-680J	C21-68P	19

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D101	Silicon	13327	1N4139	RF-34	19
D102	Silicon	13327	1N4139	RF-34	19
D103	Silicon	01295	1N645	RF-14	19
D104	Silicon	01295	1N645	RF-14	19
D105	Silicon	01295	1N645	RF-14	19
D106	Silicon	01295	1N645	RF-14	19
D107	Silicon	01295	1N645	RF-14	19
D108	Silicon	01295	1N645	RF-14	19
D109	Silicon	01295	1N645	RF-14	19
D110	Zener	04713	1N936	DZ-5	19
D111	Silicon	02735	1N3255	RF-17	19
D112	Silicon	01295	1N645	RF-14	19
D113	Not Used				

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
F101 (117V)	Fuse, slow blow, 3/8 A	71400	Type MDL	FU-18	3
F101 (234V)	Fuse, quick acting, 200 mA	75915	361.200	FU-24	3
---	Fuse Holder	75915	342012	FH-3	-
P101	Cord Set, 6 feet	93656	4638-13	CO-5	3
S101	Slide Switch, 117-234V	80164	SW-151	SW-151	3
S102	Toggle Switch, POWER	80164	SW-265	SW-265	2
T101	Power Transformer	80164	TR-114	TR-114	16

POWER SUPPLY PARTS LIST
"100" SERIES, PC-210
RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R101	6.8 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-6.8K	19
R102	0.2 Ω	±10%, 4.25 W	TCu	91637	CW-2	R151-0.2	19
R103	10 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-10K	19
R104	1.1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1.1K	19
R105	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	19
R106	100 Ω	1%, 1/8 W	MtF	07716	CEA	R88-100	19
R107	150 Ω	1%, 1/8 W	MtF	07716	CEA	R88-150	19
R108	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	19
R109	3 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-3	19
R110	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	19
R111	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	19
R112	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	19
R113	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	19
R114	4.75 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.75K	19
R115	2 kΩ	20%, 2 W	WWVar	71450	1NS 115	RP50-2K	19
R116	8.06 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-8.06K	19
R117	18.2 kΩ	1%, 1/8 W	MtF	07716	CEA-TO-18.2kΩ	R88-18.2K	19
R118	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	19
R119	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	19
R120	3 Ω	1%, 1/2 W	DCb	91637	DCF-1/2	R12-3	19
R121	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	19
R122	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	19
R123	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5 K	19
R124	82 Ω	10%, 1/2 W	Comp	01121	EB	R1-82	19
R125	1 MΩ	10%, 1/4 W	Comp	44655	RC07	R76-1M	19
R126	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	19
R127	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	19
R128	80.6 kΩ	1%, 1/2 W	MtF	07716	CEC	R94-80.6K	19
R129	7.32 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.32K	19
R130	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R131	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	19
R132	12 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	19
R133	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	19

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q101	02735	2N5183	TG-68	19
Q102	71279	ES-5321	TG-54	19
Q103	07263	2N3565	TG-39	19
Q104	07263	2N3565	TG-39	19
Q105	07263	S17638	TG-33	19
Q106	07263	2N3565	TG-39	19
Q107	02734	40317	TG-43	19
Q108	07263	2N3565	TG-39	19
Q109	07263	2N3565	TG-39	19
Q110	07263	S17638	TG-33	19
Q111	02734	40319	TG-50	19
Q112	07263	S17638	TG-33	19
Q113	07263	S17638	TG-33	19
Q114	07263	2N3565	TG-39	19
Q115	07263	2N3565	TG-39	19

POWER SUPPLY PARTS LIST
"100" SERIES, PC-210
TRANSISTORS (cont'd)

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q116	07263	S17638	TG-33	19
Q117	07263	S17638	TG-33	19
Q118	02735	40346	TG-44	19
Q119	02735	40346	TG-44	19
Q120	07263	2N3565	TG-39	19

POLARITY BOARD PARTS LIST
("200" Series, PC-207)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C201	150 pF	600 V	CerD	72982	ED-150	C22-150P	17
C202	150 pF	600 V	CerD	72982	ED-150	C22-150P	17

INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA201	Dual J-K Flip-Flop	04713	MC890P	IC-8	17
QA202	Quad 2 Input Gate	04713	MC824P	IC-5	17
QA203	Quad 2 Input Gate	04713	MC824P	IC-5	17
QA204	Quad 2 Input Gate	04713	MC824P	IC-5	17
QA205	Not Used				
QA206	Dual J-K Flip-Flop	04713	MC890P	IC-8	17
QA207	Dual 3 Input Buffer, non-inverting	04713	MC888P	IC-6	17
QA301	Dual J-K Flip-Flop	04713	MC890P	IC-8	17
QA302	Dual J-K Flip-Flop	04713	MC890P	IC-8	17
QA303	Quad 2 Input Gate	04713	MC824P	IC-5	17
QA304	Hex Inverter	04713	MC889P	IC-7	17

LAMPS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
DS201	± Polarity Pilot Light	91802	2330 Series	PL-43	17

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R201	270	10%, 1/2 W	Comp	44655	RC07	R76-270	17
R202	2.2	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	17
R203	1.5	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	17
R204	1.5	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	17

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q201	02735	2N5184	TG-67	17
Q202	02735	2N5184	TG-67	17

THOUSAND BOARD PARTS LIST
("300" Series, PC-208)

INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA301	Dual J-K Flip-Flop	04713	MC890P	IC-8	18
QA302	Dual J-K Flip-Flop	04713	MC890P	IC-8	18
QA303	Quad 2 Input Gate	04713	MC824P	IC-5	18
QA304	Hex Inverter	04713	MC889P	IC-7	18

LAMPS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
DS301	Pilot Light, front panel thousands tube	80164	PL-42	PL-42	18

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R301	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	18
R302	100 kΩ	10%, 1 W	Comp	01121	GB	R2-100K	18

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q301	02735	2N5184	TG-67	18

READOUT BOARD PARTS LIST
("400" Series, PC-229)

CONNECTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
P401	Plug, 6 pins, connects to J1206	73690	02-006-105-6-200	CS-223	24
P402	Plug, 22 pins, connects to J1207	73690	02-006-105-6-200	CS-222	24

INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA401	Dual J-K Flip-Flop	04713	MC891P	IC-9	24
QA402	Dual J-K Flip-Flop	04713	MC891P	IC-9	24
QA403	Dual J-K Flip-Flop	04713	MC891P	IC-9	24
QA404	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA405	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA406	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA407	Quad 2 Input Gate	04713	MC824P	IC-5	24
QA408	Quad 2 Input Gate	04713	MC824P	IC-5	24
QA409	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA410	Dual J-K Flip-Flop	04713	MC890P	IC-8	24

READOUT BOARD PARTS LIST
"400" SERIES, PC-229
INTEGRATED CIRCUITS (cont'd)

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA411	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA412	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA413	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA414	Dual J-K Flip-Flop	04713	MC890P	IC-8	24
QA415	Decimal Decoder/Driver	07263	U6B996079X	IC-3	24
QA416	Decimal Decoder/Driver	07263	U6B996079X	IC-3	24
QA417	Decimal Decoder/Driver	07263	U6B996079X	IC-3	24

READOUT TUBES

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
V401	Units Readout Tube	83594	B5750	EV-5750	24
V402	Tens Readout Tube	83594	B5750	EV-5750	24
V403	Hundreds Readout Tube	83594	B5750	EV-5750	24

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R401	10 kΩ	5%, 1/2 W	Comp	01121	EB	R19-10K	24
R402	10 kΩ	5%, 1/2 W	Comp	01121	EB	R19-10K	24
R403	10 kΩ	5%, 1/2 W	Comp	01121	EB	R19-10K	24

OSCILLATOR BOARD PARTS LIST
("500" Series, PC-217)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C501	.0022 µF	100 V	Poly	13934	E3FR-222-1-C	C152-.0022M	20
C502	.001 µF	100 V	Poly	13934	E3FR-222-1-C	C152-.001M	20
C503	4.5-25 pF	500 V	CerTrimmer	71590	802AZ	C76-4.5-25P	20
C504	22 pF	500 V	Mica	84171	DM15-220J	C21-22P	20
C505	470 pF	600 V	CerD	72982	ED-470	C22-470P	20
C506	220 pF	600 V	CerD	72982	ED-220	C22-220P	20
C507	56 µF	15 V	ETT	17554	CCZ01556610	C234-56M	20
C508	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	20

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D501	Diode, Silicon	01295	1N645	RF-14	20
D502	Diode, Silicon	01295	1N645	RF-14	20
D503	Diode, Silicon	01295	1N914	RF-14	20
J501	Not Used				
QA501	Quad 2 Input Gate	04713	MC824P	IC-5	20
QA502	Quad 2 Input Gate	04713	MC824P	IC-5	20
Y501	Crystal, 60 Hz	80164	CR-1	CR-1	20
	Crystal, 50 Hz	80164	CR-2	CR-2	20

OSCILLATOR BOARD PARTS LIST
"500" SERIES, PC-217
RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R501	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	20
R502	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	20
R503	68.1 Ω	1%, 1/8 W	MtF	07716	CEA	R88-68.1	20
R504	4.99 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.99K	20
R505	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	20
R506	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	20
R507	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1K	20
R508	470 Ω	10%, 1/4 W	Comp	44655	RC07	R76-470	20
R509	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	20
R510	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	20
R511	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	20
R512	470 Ω	10%, 1/4 W	Comp	44655	RC07	R76-470	20
R513	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	20
R514	470 Ω	10%, 1/4 W	Comp	44655	RC07	R76-470	20
R515	237 Ω	1%, 1/8 W	MtF	07716	CEA	R88-236	20
R516	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1K	20
R517	4.99 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.99K	20
R518	56 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-56K	20
R519	237 Ω	1%, 1/8 W	MtF	07716	CEA	R88-237	20
R520	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	20
R521	Not Used						
R522	Not Used						
R523	Not Used						
R524	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	20
R525	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	20
R526	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	20
R527	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	20
R528	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	20
R529	330 Ω	10%, 1/4 W	Comp	44655	RC07	R76-330	20
R530	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	20
R531	5.6 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-5.6K	20
R532	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	20
R533	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10	20
R534	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	20
R535	100 Ω	1%, 1/8 W	MtF	07716	CEA	R88-100	20
R536	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	20
R537	33 Ω	10%, 1/4 W	Comp	44655	RC07	R76-33	20
R538	4.02 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.02K	20

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q501	07263	2N5134	TG-65	20
Q502	07263	2N5134	TG-65	20
Q503	07263	2N5134	TG-65	20
Q504	07263	2N5139	TG-66	20
Q505	07263	2N5134	TG-65	20
Q506	07263	2N5139	TG-66	20
Q507	07263	2N5134	TG-65	20
Q508	07263	2N5139	TG-66	20
Q509	07263	2N5134	TG-65	20
Q510	07263	2N5134	TG-65	20

OSCILLATOR BOARD PARTS LIST
"500" SERIES, PC-217
TRANSISTORS (cont'd)

Circuit Desig.		Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q511	Not Used				
Q512	Not Used				
Q513		07263	2N5134	TG-65	20
Q514		03508	2N2646	TG-52	20

INTEGRATOR BOARD PARTS LIST
("600" Series, PC-219)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C601	100 pF	600 V	CerD	72982	ED-100	C22-100P	21
C602	10 pF	500 V	Poly	71590	CPR-10J	C138-10P	21
C603	0.082 µF	100 V	Poly	13934	E3FR-22-1-C	C152-.082M	21
C604	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	21
C605	220 pF	600 V	CerD	72982	ED-220	C22-220P	21
C606	220 pF	600 V	CerD	72982	ED-220	C22-220P	21
C607	.0047 µF	600 V	CerD	72982	ED-.0047	C22-.0047M	21
C608	0.1 µF	250 V		73445	C280AE/P100K	C178-.1M	21
C609	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	21
C610	22 pF	1000 V	CerD	56289	5GAQ22	C72-22P	21
C611	0.1 µF	250 V		73445	C280AE/P100K	C178-.1M	21
C612	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	21
C613	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	21
C614	22 µF	10 V	ETT	17554	TSD2-10-226	C180-22M	21

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
D601	Zener	04713	1N936	DZ-5	21
D602	Zener	04713	1N936	DZ-5	21
D603	Silicon	07263	2N3565	TG-39	21
D604	Silicon	07263	2N3565	TG-39	21
D605	Silicon	01295	1N645	RF-14	21
D606	Silicon	01295	1N645	RF-14	21
D607	Silicon	01295	1N914	RF-28	21
D608	Silicon	01295	1N914	RF-28	21
D609	Silicon	01295	1N645	RF-14	21
D610	Silicon	01295	1N645	RF-14	21
D611	Silicon	01295	1N645	RF-14	21
D612	Silicon	01295	1N645	RF-14	21
D613	Silicon	01295	1N914	RF-28	21
D614	Silicon	01295	1N914	RF-28	21
D615	Silicon	01295	1N645	RF-14	21

INTEGRATOR BOARD PARTS LIST
"600" SERIES, PC-217
INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA601	Integrated Circuit	12040	LM-201	IC-2	21
QA602	Integrated Circuit	12040	LM-201	IC-2	21
QA603	High Speed Differential Comparator	07263	U5B771039X	IC-4	21
QA605	Quad 2 Input Gate	04713	MC824P	IC-5	21

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R601	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	21
R602	*	1%, 1/8 W	MtF	91637	MMF-1/8	R177-*	21
R603	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R604	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R605	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R606	10 kΩ	±20%, 3/4 W	Cermet	73138	77PR10K	RP64-10K	21
R607	*	1%, 1/8 W	MtF	91637	MMF-1/8	R177-*	21
R608	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R609	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R610	7.5 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-7.5K	21
R611	10 kΩ	±20%, 3/4 W	Cermet	73138	77PR10K	RP64-10K	21
R612	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	21
R613	Not Used						
R614	499 Ω	1%, 1/8 W	MtF	07716	CEA	R88-499	21
R615	49.9 kΩ	1%, 1/8 W	MtF	91637	MMF-1/8	R177-49.9K	21
R616	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	21
R617	680 Ω	10%, 1/4 W	Comp	44655	RC07	R76-680	21
R618	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	21
R619	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	21
R620	33 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-33K	21
R621	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	21
R622	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	21
R623	4.7 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-4.7K	21
R624	49.9 kΩ	1%, 1/8 W	MtF	91637	MMF-1/8	R177-49.9K	21
R625	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	21
R626	237 Ω	1%, 1/8 W	MtF	07716	CEA	R88-237	21
R627	301 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-301K	21
R628	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	21
R629	100 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-100K	21
R630	158 Ω	1%, 1/8 W	MtF	07716	CEA	R88-158	21
R631	158 Ω	1%, 1/8 W	MtF	07716	CEA	R88-158	21
R632	200 Ω	±20%, 3/4 W	Cermet	73138	77PR200	RP64-200	21
R633	301 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-301K	21
R634	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	21
R635	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	21
R636	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	21
R637	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	21
R638	47 Ω	10%, 1/4 W	Comp	44655	RC07	R76-47	21
R639	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	21
R640	1.5 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1.5K	21

INTEGRATOR BOARD PARTS LIST
"600" SERIES, PC-217
RESISTORS (cont'd)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R641	100 Ω	10%, 1/4 W	Comp	44655	RC07	R76-100	21
R642	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	21
R643	3.01 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-3.01K	21
R644	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1K	21
R645	5.6 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-5.6K	21
R646	5.6 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-5.6K	21
R647	10 Ω	10%, 1/4 W	Comp	44655	RC07	R76-10	21
R648	402 Ω	1%, 1/8 W	MtF	07716	CEA	R88-402	21
R649	200 Ω	±20%, 3/4 W	Cermet	73138	77PR200	RP64-200	21
R650	402 Ω	1%, 1/8 W	MtF	07716	CEA	R88-402	21
R651	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	21
R652	820 Ω	10%, 1/4 W	Comp	44655	RC07	R76-820	21
R653	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	21
R654	220 Ω	10%, 1/4 W	Comp	44655	RC07	R76-220	21
R655	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	21
R656	6.98 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-6.98K	21
R657	6.04 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-6.04K	21

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q601	07263	2N5139	TG-66	21
Q602	07263	2N5139	TG-66	21
Q603	07263	2N5134	TG-65	21
Q604	07263	2N5134	TG-65	21
Q605	04713	2N4220	TG-42	21
Q606	04713	2N4220	TG-42	21
Q607	01295	SF5043	TG-40	21
Q608	01295	SF5043	TG-40	21
Q609	07263	S17638	TG-33	21

MODEL 4401 OUTPUT BUFFER BOARD PARTS LIST
("1000" Series, PC-218)

NOTE

On schematic diagram 23457D there are 15 buffers labeled 'A' through 'P' not including 'I'. Each buffer is composed of 4 resistors and 3 transistors. A sample buffer circuit is given in the lower left hand corner of the schematic. Following is a sample replaceable parts list for each buffer.

BUFFER RESISTORS (A thru P)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R1001	180 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-180K	26
R1002	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	26
R1003	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	26
R1004	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	26

MODEL 4401 OUTPUT BUFFER PARTS LIST
"1000" SERIES, PC-218
BUFFER TRANSISTORS (A thru P)

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q1001	07263	2N3565	TG-39	26
Q1002	07263	2N3565	TG-39	26
Q1003	07263	2N3565	TG-39	26

MODEL 4401 OUTPUT BUFFER BOARD PARTS LIST
("1100" Series, PC-209)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
C1101	.001 µF	600 V	CerD	72982	ED-.001	C22-.001M	25
C1102	.0033 µF	600 V	CerD	72982	ED-.0033	C22-.0033M	25
C1103	.001 µF	600 V	CerD	72982	ED-.001	C22-.001M	25
C1104	0.1 µF	250 V		73445	C280AE/P100K	C178-0.1M	25
C1105	100 pF	600 V	CerD	72982	ED-100	C22-100P	25
C1106	100 pF	600 V	CerD	72982	ED-100	C22-100P	25
C1107	470 pF	600 V	CerD	72982	ED-470	C22-470P	25
C1108	470 pF	600 V	CerD	72982	ED-470	C22-470P	25
C1109	22 µF	10 V	ETT	17554	TSD2-10-226	C180-22M	25
C1110	10 µF	20 V	ETT	17554	TSD2-20-106	C179-10M	25

INTEGRATED CIRCUITS

Circuit Desig.	Description	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
QA1101	Quad 2 Input Gate	04713	MC824P	IC-5	25
QA1102	Quad 2 Input Gate	04713	MC824P	IC-5	25

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R1101	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	25
R1102	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	25
R1103	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	25
R1104	3.3 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.3K	25
R1105	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	25
R1106	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	25
R1107	180 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-180K	25
R1108	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	25
R1109	1 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-1K	25
R1110	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	25
R1111	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	25
R1112	180 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-180K	25
R1113	2.2 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-2.2K	25
R1114	6.98 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-6.98K	25
R1115	6.04 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-6.04K	25
R1116	2 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-2K	25
R1117	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	25
R1118	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	25
R1119	180 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-180K	25
R1120	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	25

MODEL 4401 OUTPUT BUFFER PARTS LIST
"1100" SERIES, PC-209
TRANSISTORS

Circuit Desig.		Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q1101					
Q1102		07263	2N3565	TG-39	25
Q1103	Not Used	07263	2N3565	TG-39	25
Q1104					
Q1105		07263	2N3565	TG-39	25
		07263	2N3565	TG-39	25
Q1106					
Q1107		07263	2N3565	TG-39	25
Q1108		07263	2N3565	TG-39	25
Q1109		07263	2N3565	TG-39	25
Q1110		07263	2N3565	TG-39	25
		07263	2N3565	TG-39	25

NOTE

On schematic diagram 23481E there are 6 buffers labeled 'A' through 'F'. Each buffer is composed of 5 resistors and 3 transistors. A sample buffer circuit is given on the schematic. Following is a sample replaceable parts list for each buffer.

BUFFER RESISTORS (A thru F)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
R1121	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	25
R1122	120 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-120K	25
R1123	10 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-10K	25
R1124	180 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-180K	25
R1125	3.9 kΩ	10%, 1/4 W	Comp	44655	RC07	R76-3.9K	25

BUFFER TRANSISTORS (A thru F)

Circuit Desig.	Mfr. Code	Mfr. Part No.	Keithley Part No.	Fig. Ref.
Q1111				
Q1112	07263	2N3565	TG-39	25
Q1113	07263	2N3565	TG-39	25
	07263	2N3565	TG-39	25

CODE TO NAME LIST.

Code List of Suggested Manufacturers. (Based on Federal Supply Code for Manufacturers, Cataloging Handbook H4-1).

01121	Allen-Bradley Corp. 1201 South 2nd Street Milwaukee, Wis. 53204
01295	Texas Instruments, Inc. Semiconductor-Components Div. 13500 N. Central Expressway Dallas, Texas 75231
01686	RCL Electronics, Inc. 195 McGregor Street Manchester, N.H. 03102
02660	Amphenol Electronics, Corp. 2801 South 25th Avenue Broadview, Ill. 60153
02734	Radio Corp. of America Defense Electronic Products Camden, New Jersey
02735	Radio Corp. of America Commercial Receiving Tube & Semiconductor Division Somerville, N.J.
03508	General Electric Company Semiconductor Products Dept. Electronics Park Syracuse, New York 13201
04713	Motorola Semiconductor Products, Inc. 5005 East McDowell Road Phoenix, Ariz. 85008
05397	Union Carbide Corp. Electronics Division 270 Park Avenue New York, New York 10017
07263	Fairchild Camera & Instrument Corp., Semiconductor Division 313 Frontage Road Mountain View, Calif.
07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601
09922	Burndy Corp. Richards Avenue Norwalk, Conn. 06852
12040	National Semiconductor Corp. Commerce Drive Post Office Box 443 Danbury, Conn. 06813
13050	Potter Co. Highway 51 N. Wesson, Miss. 39191
13327	Solitron Devices, Inc. 256 Oak Tree Road Tappan, New York 10983
13934	Midwec Corp. 602 Main Oshkosh, Nebr. 69154
17554	Components, Inc. Smith Street Biddeford, Maine 04005
24655	General Radio Co. 22 Baker Avenue West Concord, Mass. 01781
27682	Hathaway Instruments, Inc. 5800 E. Jewell Avenue Denver, Colorado 80222
44655	Ohmite Mfg. Co. 3601 Howard Street Skokie, Illinois 60076
56289	Sprague Electric Co. North Adams, Mass.
58474	Superior Electric Co., The 383 Middle Street Bristol, Conn. 06012
71279	Cambridge Thermionic Corp. 430 Concord Avenue Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. 2538 W. University Street St. Louis, Mo.
71450	CTS Corp. 1142 W. Beardsley Avenue Elkhart, Ind.
71590	Centralab Division of Globe-Union, Inc. 932 E. Keefe Avenue Milwaukee, Wis. 53212
72982	Erie Technological Products, Inc. 644 W. 12th Street Erie, Pa. 16512
73138	Beckman Instruments, Inc. Helipot Division 2500 Harbor Blvd. Fullerton, Calif. 92634
73445	Amperex Electronic Co., Div. of North American Philips Co. Hicksville, N.Y.
73690	Elco Resistor Co. 1158 Broadway New York, New York
75915	Littlefuse, Inc. 800 E. Northwest Highway Des Plaines, Ill. 60016
80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139
83594	Burroughs Corp. Electronic Components Div. Post Office Box 1226 Plainfield, N.J. 07061
84171	Arco Electronics, Inc. Community Drive Great Neck, N.Y. 11022
84790	Dura Corp. Implement Div.-P.O. Box 231 Zanesville, Ohio 43702
90201	Mallory Capacitor 3029 West Washington Post Office Box 372 Indianapolis, Ind. 46206
91637	Dale Electronics, Inc. Post Office Box 609 Columbus, Nebr. 68601
91662	Elco Corp. Willow Grove, Pa.
91802	Industrial Devices, Inc. 982 River Road Edgewater, New Jersey 07020
93656	Electric Cord Co. 1275 Bloomfield Avenue Caldwell, N.J.
95712	Dage Electric Co., Inc. Hurricane Road Franklin, Indiana

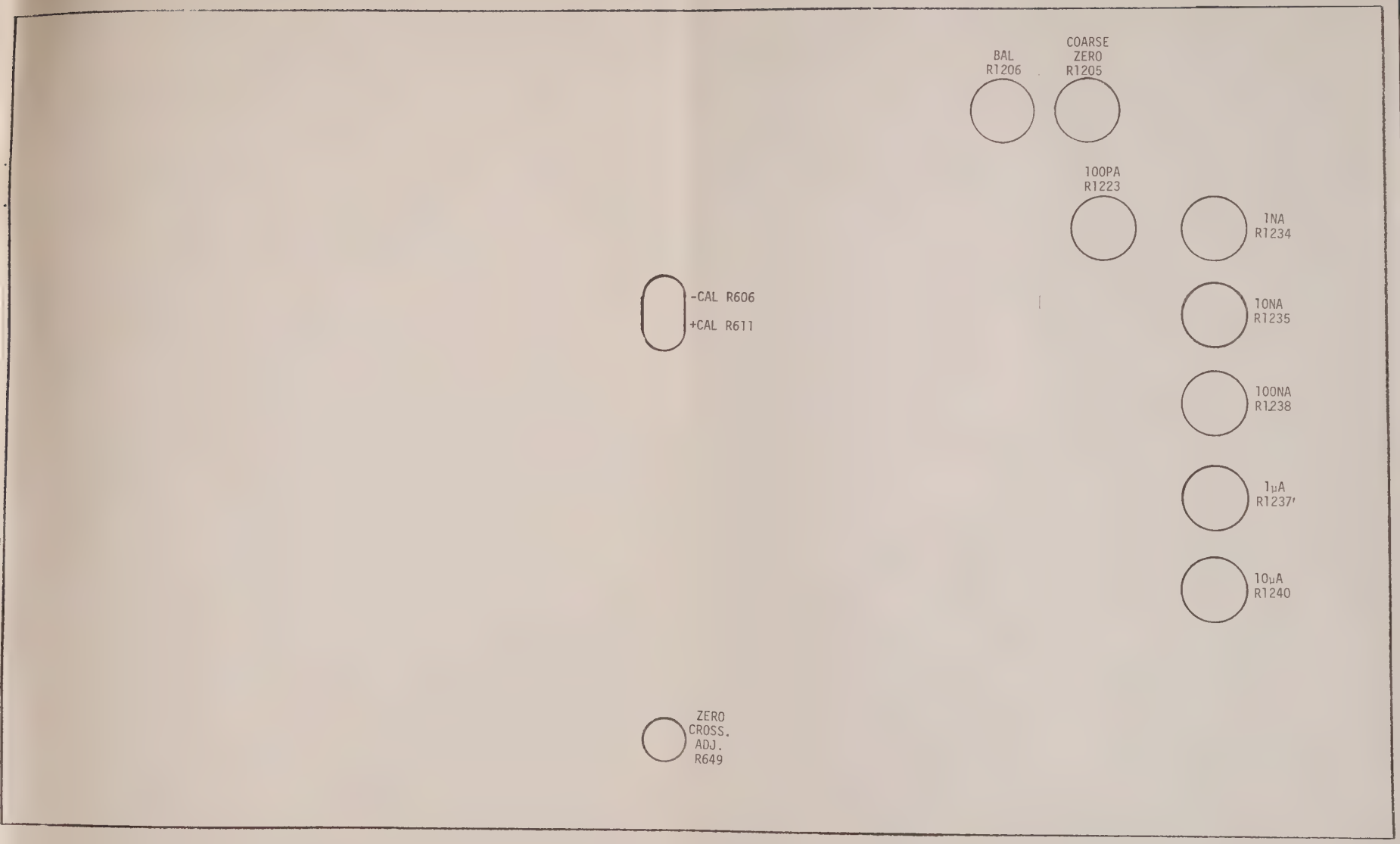
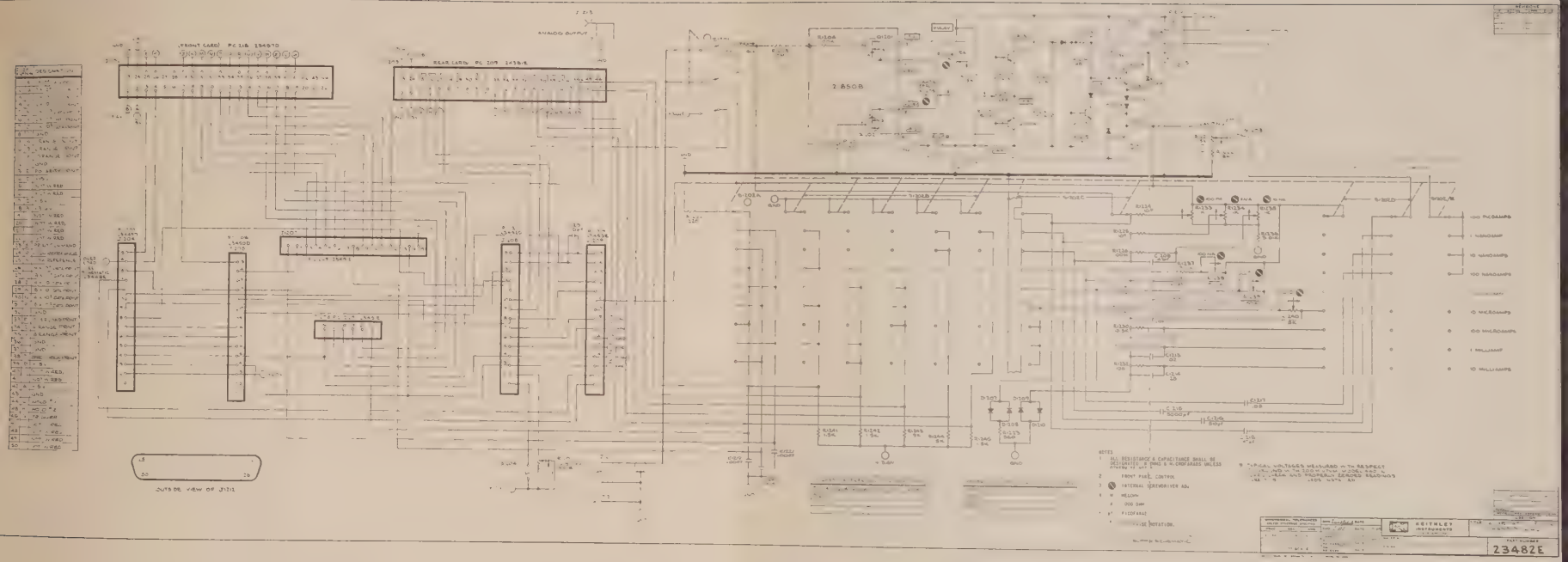
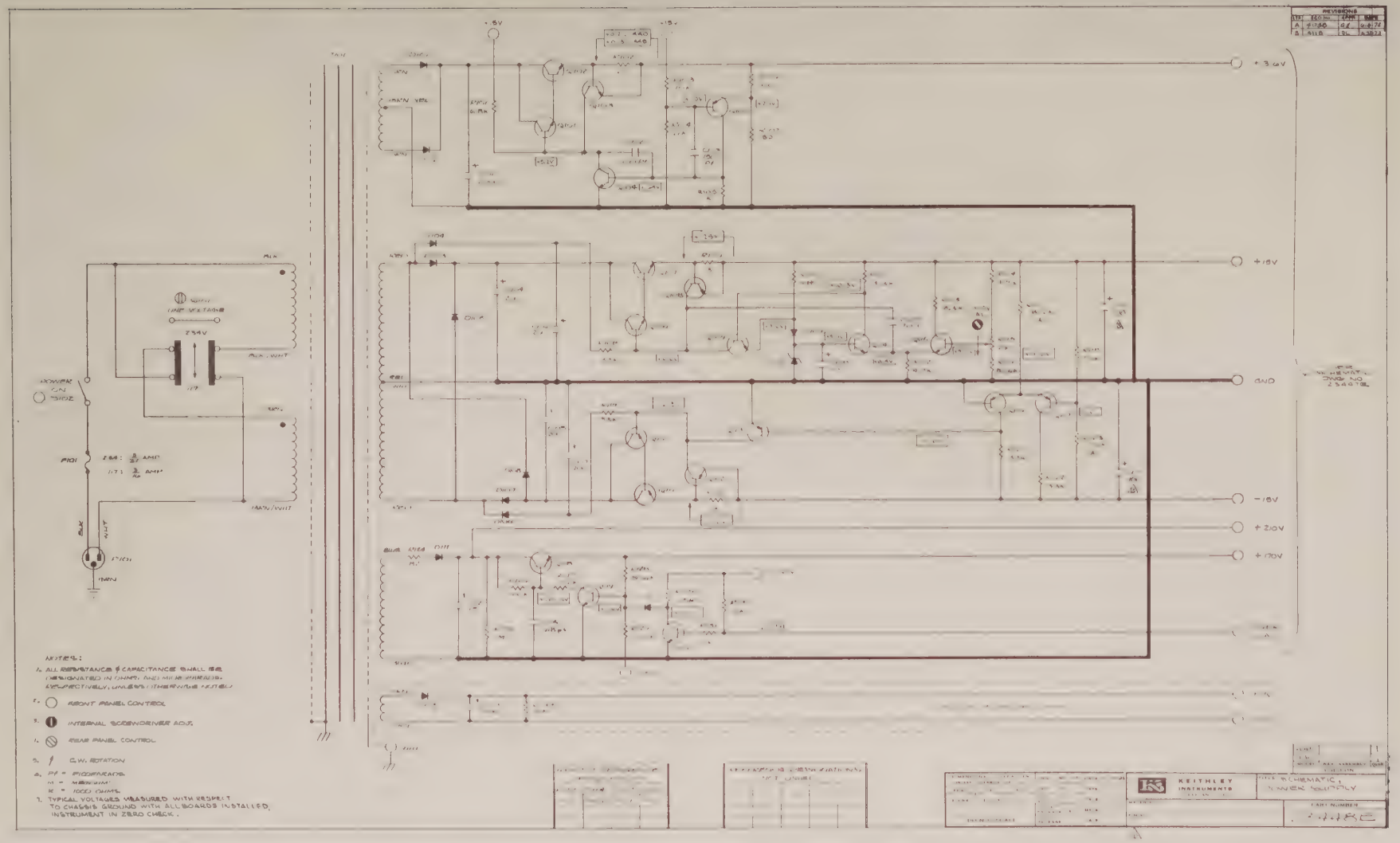
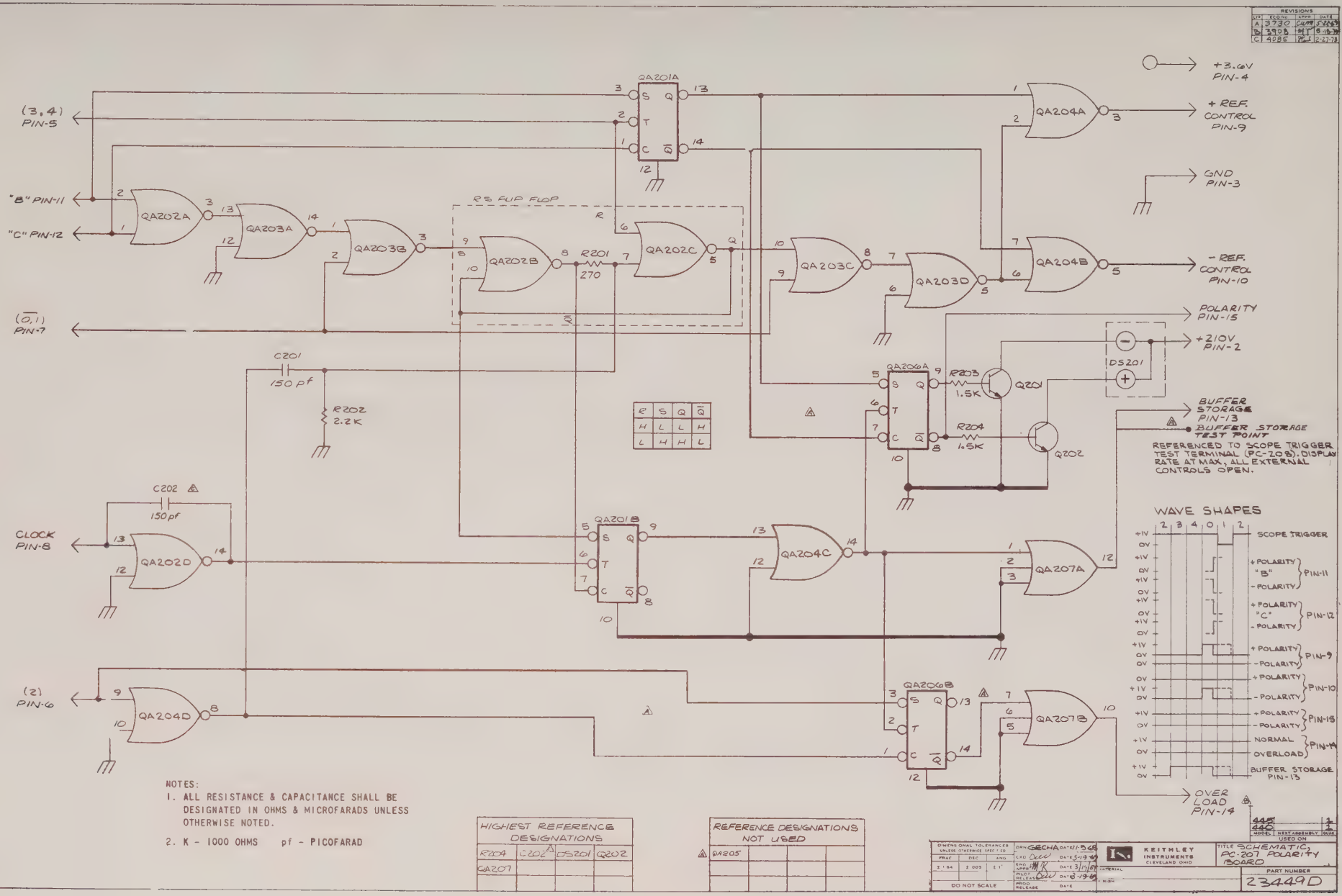


FIGURE 30. Template, Top Cover.

FIGURE 31. Template, Bottom Cover.


FRONT CARD PC 318 23497D
REAR CARD PC 209 24381E
OUTSIDE VIEW OF J1/J2
2.850B
100 PICOAMPS
1 NANOAMP
10 NANOAMPS
100 NANOAMPS
1 MICROAMP
10 MICROAMPS
100 MICROAMPS
1 MILLIAMP
10 MILLIAMPS
NOTES
1 ALL RESISTANCE & CAPACITANCE SHALL BE INDICATED AS OHMS & M-OHMS/FARADS UNLESS OTHERWISE NOTED
2 FRONT PANEL CONTROL
3 INTERNAL SCREWDRIVER ADJ.
4 M MEGOHM
5 200 OHM
6 P PICOFARAD
7 SEE ROTATION.
KEITHLEY INSTRUMENTS
23482E


REVISIONS
+5V
+15V
+3.6V
+15V
GND
-15V
+210V
+170V
LINE VOLTAGE
234V
POWER ON SIDE
F101
MAIN/UNIT
NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS AND MICROFARADS RESPECTIVELY, UNLESS OTHERWISE NOTED
2. FRONT PANEL CONTROL
3. INTERNAL SCREWDRIVER ADJ.
4. REAR PANEL CONTROL
5. C.W. ROTATION
6. PF = PICOFARADS
M = MEGOHM
K = 1000 OHMS
7. TYPICAL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND WITH ALL BOARDS INSTALLED, INSTRUMENT IN ZERO CHECK.
KEITHLEY INSTRUMENTS
SCHEMATIC, POWER SUPPLY



NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K - 1000 OHMS pf - PICOFARAD

HIGHEST REFERENCE DESIGNATIONS			
R204	C202	DS201	Q202
QA207			

REFERENCE DESIGNATIONS NOT USED			
QA205			

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
FRAC ± DEC ANG
± 1/64 ± .005 ± 1°
DO NOT SCALE

DRN GECHA DATE 2/13/76
CKD DCC DATE 3-19-76
ENG APPR MK DATE 3/19/76
MFG APPR DW DATE 3-19-76
PROD RELEASE DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC, PC-207 POLARITY BOARD

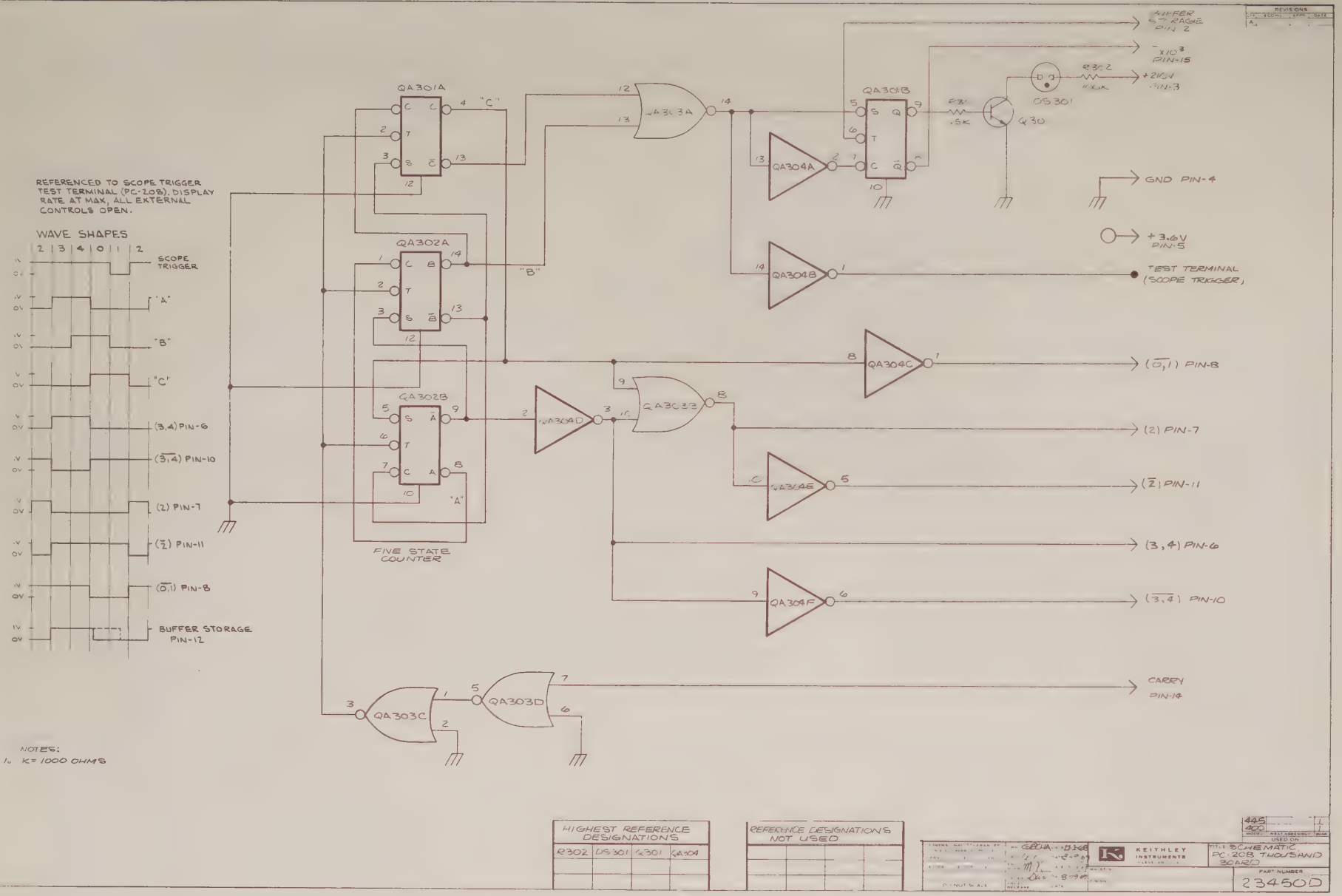
PART NUMBER 23449D

MATERIAL

FINISH

MODEL NEXT ASSEMBLY USED ON

445 1
440 2



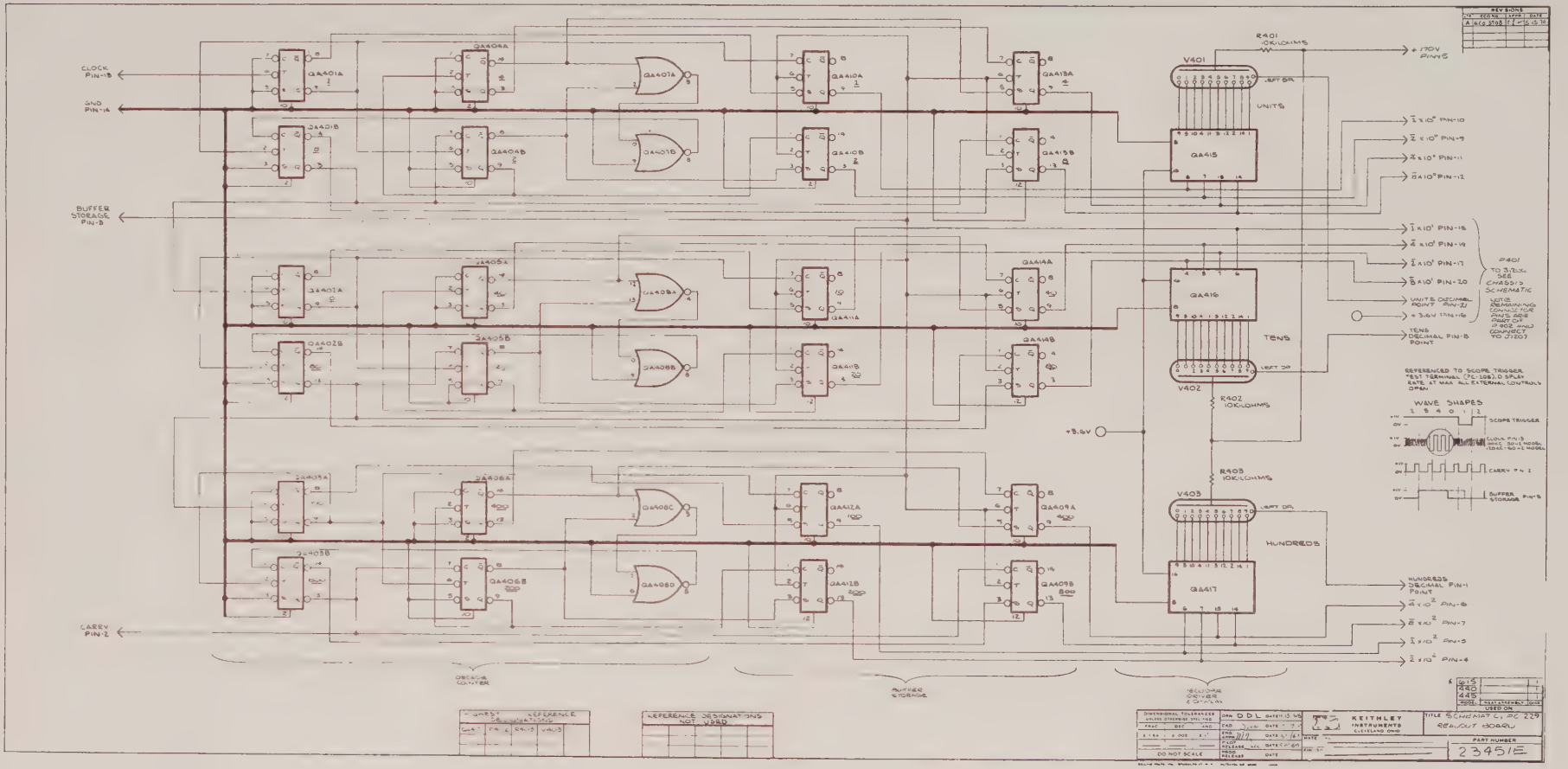
HIGHEST REFERENCE DESIGNATIONS			
R302	DS301	Q301	QA304

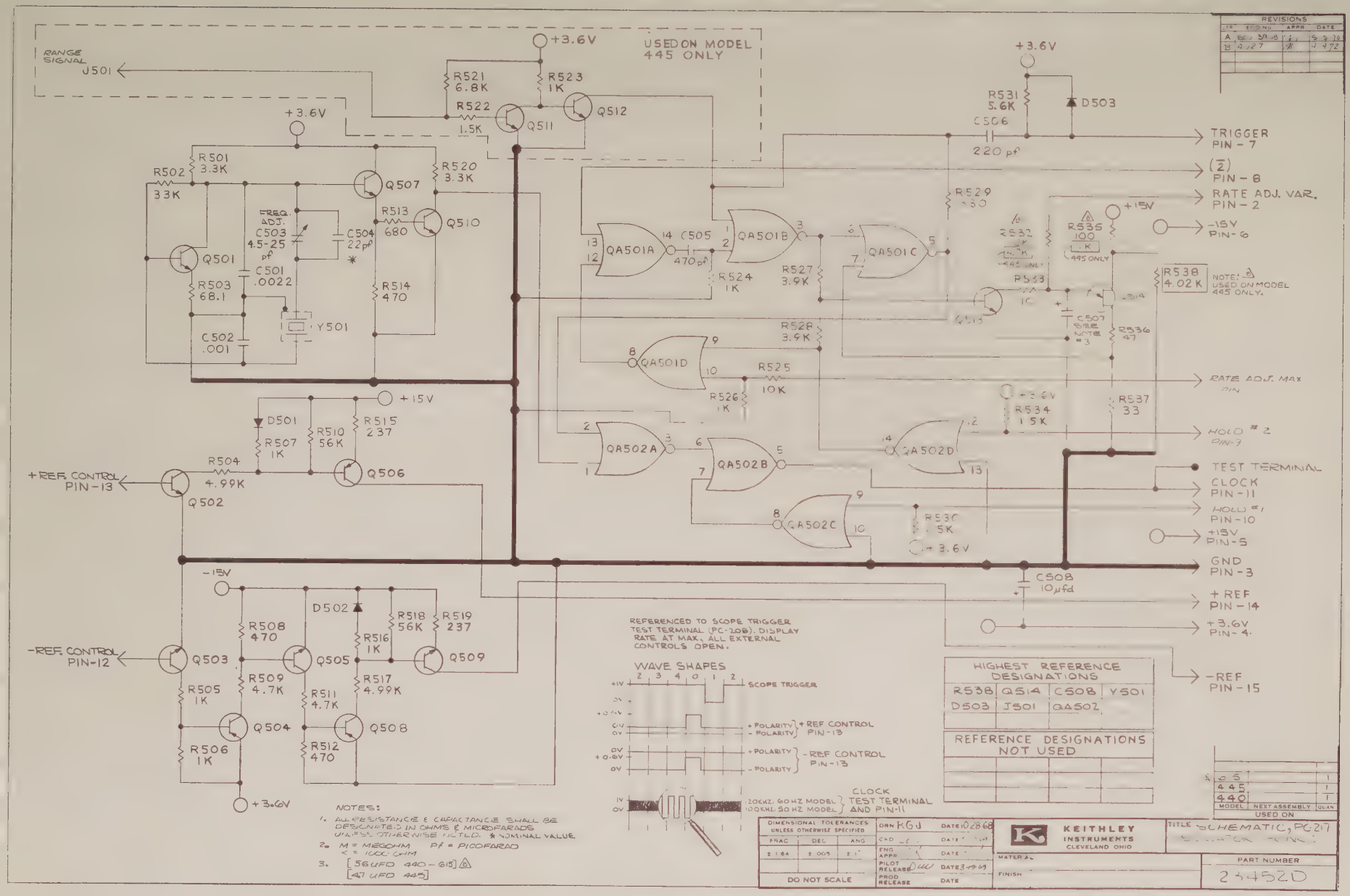
REFERENCE DESIGNATIONS NOT USED			

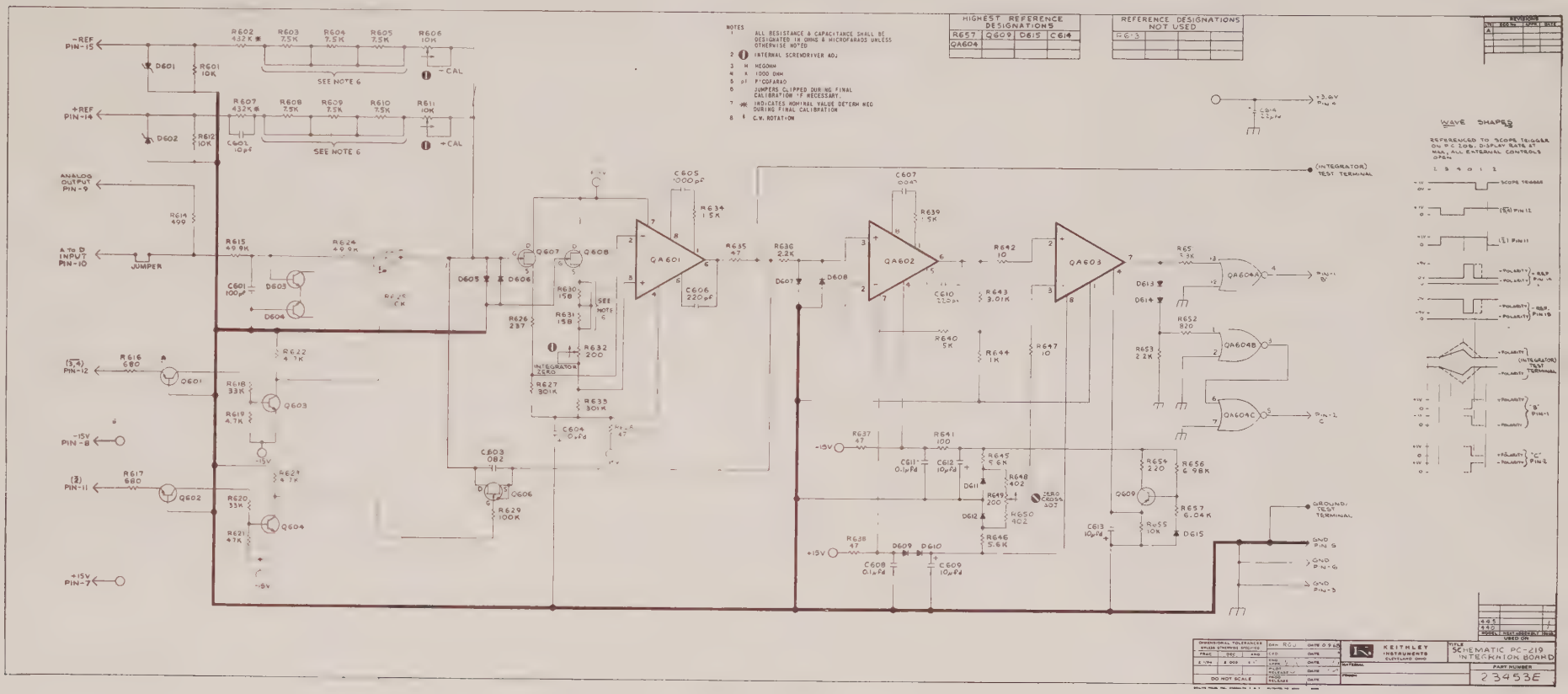
KEITHLEY INSTRUMENTS

TITLE: SCHEMATIC PC-208 THOUSAND BOARD

PART NUMBER 234508


CLOCK PIN-13
GND PIN-14
BUFFER STORAGE PIN-3
CARRY PIN-2
R401 10K LOHMS
+13.0V PIN-5
V401
UNITS
LEFT DP
Ī x10⁰ PIN-10
Z̄ x10⁰ PIN-9
Z x10⁰ PIN-11
Ā x10⁰ PIN-12
Ī x10¹ PIN-18
Z x10¹ PIN-19
Z̄ x10¹ PIN-17
Ā x10¹ PIN-20
UNITS DECIMAL POINT PIN-21
+3.6V PIN-16
TENS DECIMAL PIN-8 POINT
P401 TO 3/32K CHASSIS SCHEMATIC
NOTE REMAINING CONNECTOR PINS ARE PART OF GROUND BUS AND CONNECT TO J1107
TENS
V402
R402 10K LOHMS
+3.6V
R403 10K LOHMS
V403
HUNDREDS
HUNDREDS DECIMAL PIN-1
Ā x10² PIN-6
Z̄ x10² PIN-7
Ī x10² PIN-5
Z x10² PIN-4
REFERENCED TO SCOPE TRIGGER TEST TERMINAL (TP-108); DISPLAY RATE AT MAX ALL EXTERNAL CONTROLS OPEN
WAVE SHAPES
1 2 4 0 1 2
SCOPE TRIGGER
CLOCK PIN 13
CARRY PIN 2
BUFFER STORAGE PIN 3
DECADE COUNTER
BUFFER STORAGE
DECODER & DRIVER
REFERENCE DESIGNATIONS NOT USED
KEITHLEY INSTRUMENTS CLEVELAND OHIO
TITLE SCHEMATIC, PC 229
REV OUT BOARD
PART NUMBER 23491E


RANGE SIGNAL U501
USED ON MODEL 445 ONLY
+3.6V
R521 6.8K
R523 1K
R522 1.5K
Q511
Q512
R501 3.3K
R502 33K
R520 3.3K
Q507
R513 680
Q510
FREQ. ADJ. C503 4.5-25 pf
C504 22pf *
Q501
C501 .0022
R503 68.1
R514 470
C502 .001
Y501
+15V
D501
R507 1K
R510 56K
R515 237
R504 4.99K
+REF. CONTROL PIN-13
Q502
Q506
-15V
D502
R508 470
R518 56K
R519 237
R516 1K
-REF. CONTROL PIN-12
Q503
Q505
Q509
R505 1K
R509 4.7K
R511 4.7K
R517 4.99K
Q504
Q508
R506 1K
R512 470
+3.6V
QA501A
QA501B
QA501C
QA501D
C505 470pf
R524 1K
R527 3.9K
R528 3.9K
R525 10K
R526 1K
QA502A
QA502B
QA502C
QA502D
R529 150
R531 5.6K
D503
C506 220 pf
R532 1K
R535 100 K
R543 1K
Q513
C507 SEE NOTE #3
R536 47
R538 4.02 K
R534 1.5K
R537 33
R530 1.5K
TRIGGER PIN-7
(Z) PIN-8
RATE ADJ. VAR. PIN-2
-15V PIN-6
RATE ADJ. MAX PIN
HOLD #2 PIN-9
TEST TERMINAL
CLOCK PIN-11
HOLD #1 PIN-10
+15V PIN-5
GND PIN-3
C508 10 µfd
+REF PIN-14
+3.6V PIN-4
-REF PIN-15
REFERENCED TO SCOPE TRIGGER TEST TERMINAL (PC-208). DISPLAY RATE AT MAX., ALL EXTERNAL CONTROLS OPEN.
WAVE SHAPES
SCOPE TRIGGER
+ POLARITY
- POLARITY
+REF CONTROL PIN-13
-REF CONTROL PIN-13
20KHZ, 60 HZ MODEL
100KHZ, 50 HZ MODEL
CLOCK TEST TERMINAL AND PIN-11
NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED. % NOMINAL VALUE
2. M = MEGOHM Pf = PICOFARAD K = 1000 OHM
3. [56 UFD 440-615] [47 UFD 445]
HIGHEST REFERENCE DESIGNATIONS
R538 Q514 C508 Y501
D503 J501 QA502
REFERENCE DESIGNATIONS NOT USED
REVISIONS
LTR ECO NO APPR DATE
A EC-39-8 4-27-72
B 4327 JM 4-27-72
USED ON
C5 1
445 1
440 1
MODEL NEXT ASSEMBLY QUAN
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
FRAC ± 1/64 DEC ± .005 ANG ± 1°
DO NOT SCALE
DRN KGJ DATE 10-28-68
CHD DATE
ENG APPR DATE
PILOT RELEASE DATE 3-19-69
PROD RELEASE DATE
KEITHLEY INSTRUMENTS CLEVELAND OHIO
MATERIAL
FINISH
TITLE SCHEMATIC, PC-217 SYNCHRON ICING
PART NUMBER 24452D



NOTES

1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED
2. ⊖ INTERNAL SCREWDRIVER ADJ.
3. M MEGOHM
4. K 1000 OHM
5. pf P'COFARAD
6. JUMPERS CLIPPED DURING FINAL CALIBRATION IF NECESSARY.
7. * INDICATES NOMINAL VALUE DETERM NED DURING FINAL CALIBRATION
8. ⊖ C.W. ROTATION

HIGHEST REFERENCE DESIGNATIONS			
R657	Q609	D615	C614
QA604			

REFERENCE DESIGNATIONS NOT USED			
R6-3			

REVISIONS			
LTR	ECO'S	ZONE	DATE
A			

445	
440	
BOARD	NEXT ASSEMBLY USED ON

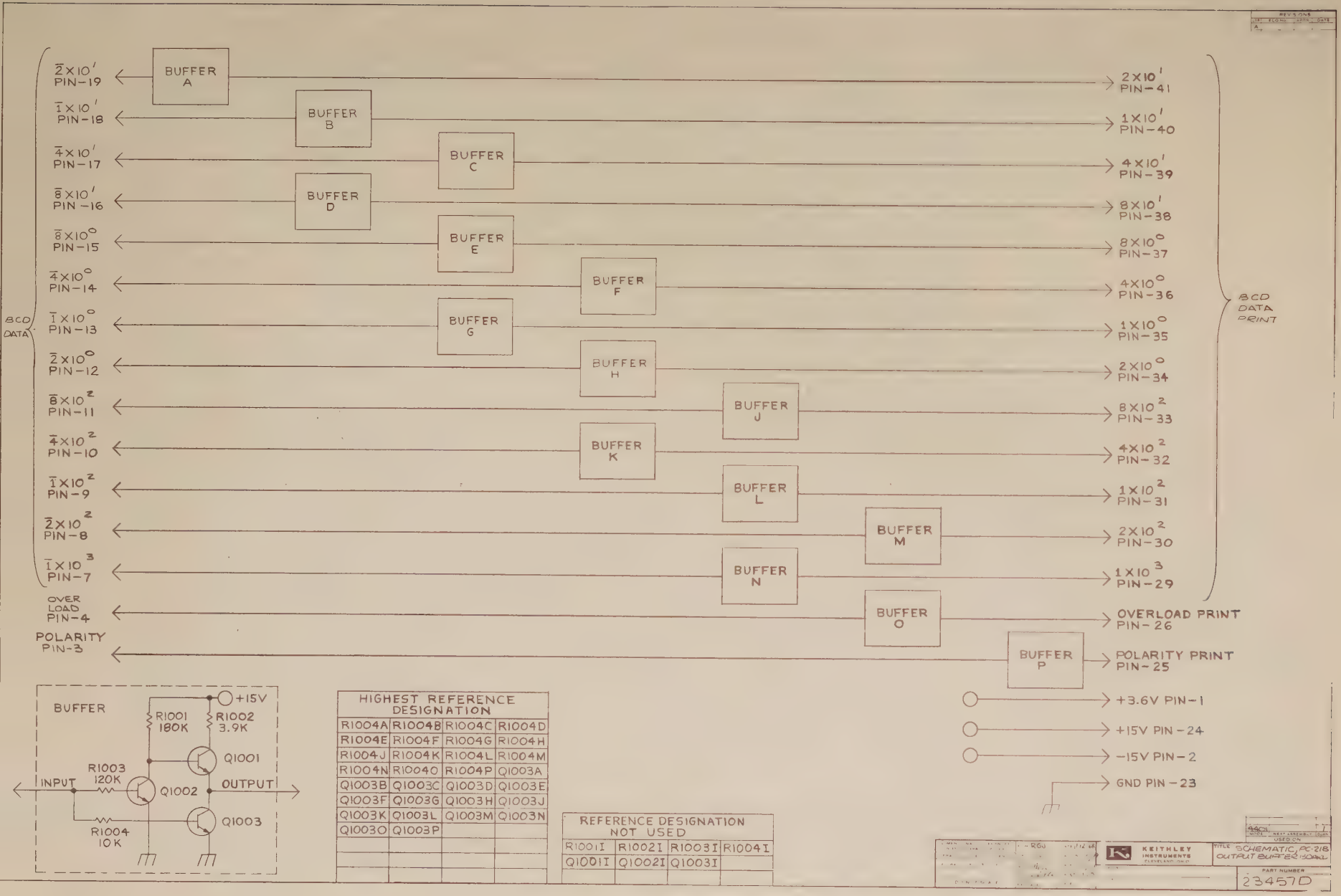
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: FRAC ±1/64, DEC .XX ±.02, .X ±.1, ANG ±1°. DO NOT SCALE.

DRN RGJ DATE 0-9-62
CHKD DATE
ENGR DATE
MFG DATE
RELEASED DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC PC-219 INTEGRATION BOARD

PART NUMBER 23453E



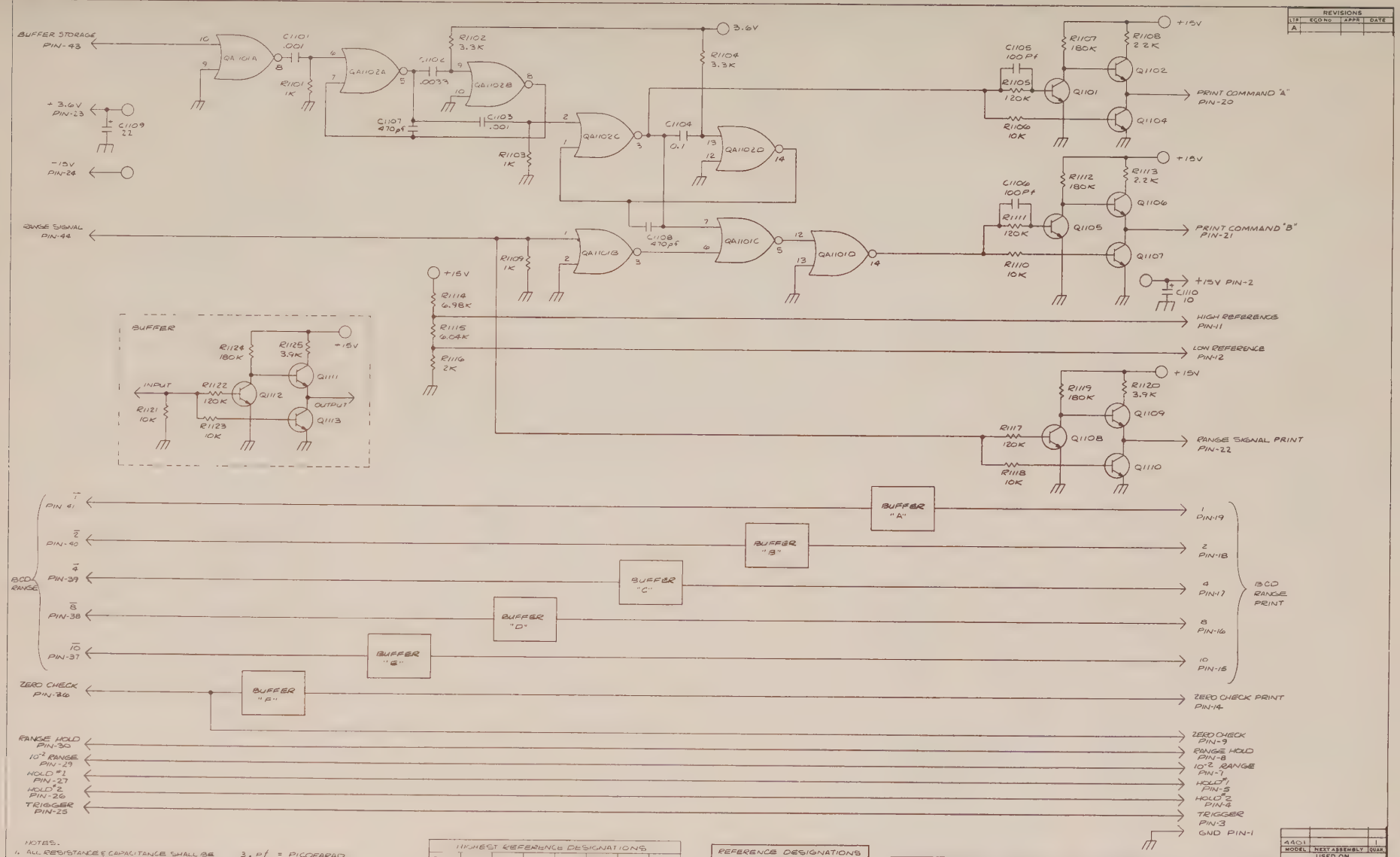
HIGHEST REFERENCE DESIGNATION			
R1004A	R1004B	R1004C	R1004D
R1004E	R1004F	R1004G	R1004H
R1004J	R1004K	R1004L	R1004M
R1004N	R1004O	R1004P	Q1003A
Q1003B	Q1003C	Q1003D	Q1003E
Q1003F	Q1003G	Q1003H	Q1003J
Q1003K	Q1003L	Q1003M	Q1003N
Q1003O	Q1003P		

REFERENCE DESIGNATION NOT USED			
R1001I	R1002I	R1003I	R1004I
Q1001I	Q1002I	Q1003I	

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE SCHEMATIC, PC-218 OUTPUT BUFFER BOARD

PART NUMBER 23457D



REVISIONS			
LTR	ECO NO	APPR	DATE
A			

NOTES.
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATION IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. K = 1000 OHM
3. pf = PICOFARAD

HIGHEST REFERENCE DESIGNATIONS

R1125A	R1125B	R1125C	R1125D	R1125E	Q1113F		
Q1113A	Q1113B	Q1113C	Q1113D	Q1113E	Q1113F		
C1110	Q1102D						

REFERENCE DESIGNATIONS NOT USED

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRAC	DEC	ANG
± 1/64	± .005	± 1°
DO NOT SCALE		

DRN	GECHA	DATE 11-3-68
CKD	[illegible]	DATE 12-6-68
ENG APPR	MK	DATE 3/17/69
PILOT RELEASE	[illegible]	DATE 4-14-69
PROD RELEASE		DATE

KEITHLEY INSTRUMENTS CLEVELAND OHIO

TITLE SCHEMATIC, PC-209 OUTPUT BUFFER BOARD

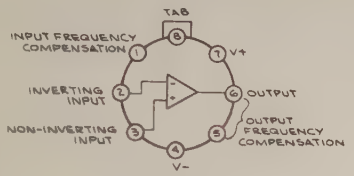
MATERIAL

FINISH

PART NUMBER 23481E

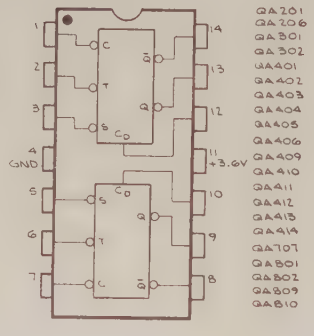
4401			1
MODEL	NEXT ASSEMBLY		QUAN
USED ON			

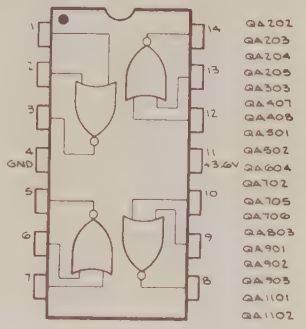
QA601
QA602

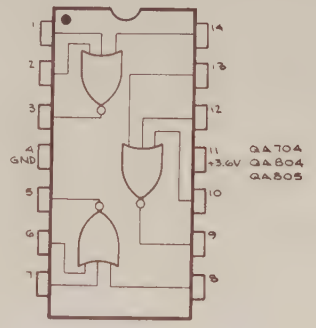


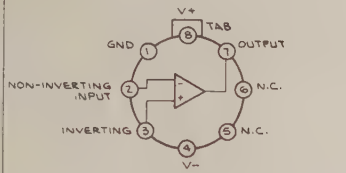
NOTE: PIN 4 CONNECTED TO BASE

Q607
Q608





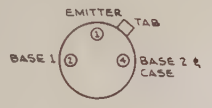




NOTE: PIN 4 CONNECTED TO CASE

QA603

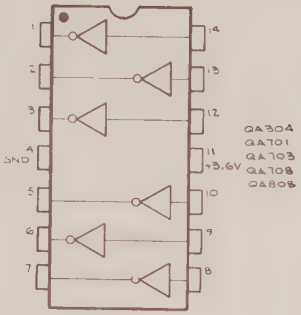
Q1205

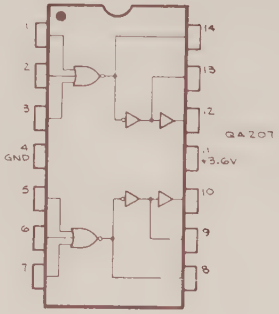


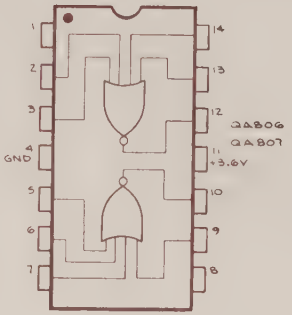
Q514

QA415
QA416
QA417

I_1, I_2, I_4, I_8 = BCD INPUTS
$Z_0 - Z_9$ = DECODED OUTPUTS







Q605
Q606

NOTE: ALL VIEWS ARE FROM THE TOP

REVISIONS				
LTR	ECO No.	APPR.	DATE
A			

DRN	DLL	DATE	1/16/68
CHK	DLL	DATE	3/13/68
APPR	MK	DATE	3/13/68
MATERIAL			
FINISH			

DO NOT SCALE

KEITHLEY INSTRUMENTS
CLEVELAND OHIO

TITLE: DIAGRAM, BASING

PART NUMBER: 23606D

448
448
MODEL NEXT ASSEMBLY USED ON

KEITHLEY INSTRUMENTS, INC.
SERVICE FORM

PO#

MODEL NO. _____ SERIAL NO. _____ DATE _____ R-

SHIP INSTRUMENT & FORM TO:

SALES SERVICE DEPT.
KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

PERSON USING THE INSTRUMENT:

NAME _____ PHONE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____ ZIP _____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____(Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.)

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

_____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____°F. Variation? _____°F. Rel. Humidity? _____
   Other? _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

KEITHLEY INSTRUMENTS, INC.

INSTRUCTION MANUAL
CHANGE NOTICE
MODEL 440 DIGITAL PICOAMMETER

INTRODUCTION: Since Keithley Instruments is continually improving product performance and reliability, it is often necessary to make changes to Instruction Manuals to reflect these improvements. Also, errors in Instruction Manuals occasionally occur that require changes. Sometimes, due to printing lead time and shipping requirements, we can't get these changes immediately into printed Manuals. The following new change information is supplied as a supplement to this Manual in order to provide the user with the latest improvements and corrections in the shortest possible time. Many users will transfer this change information directly to a Manual to minimize user error. All changes are underlined.

CHANGES:

(1) Page 46, Replaceable Parts, TRANSISTORS, change Q607 and Q608 to read as follows:
Q607, N-Channel FET (Selected TG-71), 01295, TIS70, TG-40*, 21
Q608, N-Channel FET (Selected TG-71), 01295, TIS70, TG-40*, 21
*Order as a matched pair, Keithley Part No. TG-40

(2) Page 44, Replaceable Parts, CAPACITORS, change C602 to read as follows:
C602, 5pF, 200V, Poly, 00686, E1013-1, C31-5P, 21

(3) Page 36, Replaceable Parts, DIODES, change as follows:

D1203	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19
D1204	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19
D1206	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19
D1207	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19
D1208	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19

(4) Page 38, Replaceable Parts, DIODES, change as follows

D111	Rectifier, 1A, 800V	MOT	1N4006	RF-38	19

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